THE PLANNING, CONSTRUCTION AND MAINTENANCE OF PLAYING FIELDS

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BY
PERCY WHITE SMITH
M.S.E., F.F.S. (ENG.)
CHIEF TECHNICAL ADVISER TO THE
NATIONAL PLAYING FIELDS ASSOCIATION

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FOREWORD

By SIR GEORGE L. PEPLER, C.B., PP.T.P.I., F.R.I.C.S.

THE Town and Country Planning Act, 1947, requires surveys and development (including redevelopment) plans to be prepared for every place in England, Scotland, and Wales, by 1 July 1951. Since the health and well-being of the nation require that playing fields should form an important item of such plans, this book may be said to appear at a most appropriate moment.

The author, Mr. P. W. Smith, is an expert in all matters relating to choice of site, the requirements of all types of open-air recreation, and how they can be arranged to their own and mutual advantage so as to use each site to the fullest possible extent. He also writes with authority on the problems of construction and maintenance.

For planners and all those responsible for the provision, layout, construction, or maintenance of playing fields, this volume will, therefore, serve as an invaluable text-book on requirements and methods. This, of course, is not the whole story; for example, whilst levels and soils are essential factors in choice of site, actual selection must be considered in relation to the whole plan for the place. A plan which will aim at meeting the needs of the population in relation to their homes, workplaces, cultural and communal life, and recreation, should provide for a complete system of open spaces linked with the country-side.

The book makes no pretence to teach the planners, landscape architects, or park superintendents, their business, but it does place a mass of essential information at their service. Moreover, the councillor will find it well worth his while to read the book, possibly skipping the purely technical pages, in order to inform himself as to the importance of this factor in public health and of the nature and scope of the problems involved.

The National Playing Fields Association offers this volume as the work of its expert and as a fruit of its experience of twenty-one years. That experience and the services of its small but highly skilled technical staff will in the future, as in the past, always be at the call of any body or person concerned with the provision, design, construction, or maintenance of the playing fields that our countrymen so sorely need.

AUTHOR'S PREFACE

THIS work is not intended to be a text-book on Landscape Design. The author is not concerned with the layout of Ornamental Parks, Gardens, Pleasances, and similar open spaces for more or less passive relaxation in the open air. His endeavour is mainly to outline acceptable standards in relation to the development and use of playing space by the general public, based on the experience of The National Playing Fields Association since its inception over twenty-one years ago.

In his position as Technical Adviser to the Association he has had to examine and report on a large number of playing field projects submitted by local authorities and other public organizations for approval by the Association and it became obvious that too many of those responsible for the preparation of these schemes lacked the experience and data necessary for the efficient arrangement of playing facilities. It was decided, therefore, by the Grounds and Layout Committee of the Association that as soon as practicable its recommendations in respect of all aspects of playing field development should be concisely and clearly defined so that all concerned may appreciate the Association's aims in endeavouring to meet adequately the need of the nation for outdoor physical recreation. The demand for playing facilities in the greater part of these densely populated islands is far in excess of the space at present available and strenuous efforts will be needed on the part of public authorities if the modest standards laid down by the Association are ever to be achieved. Sites available for such development must be planned to maximum capacity by avoiding any undue extravagance in the dimensions of pitches or courts while at the same time maintaining a reasonable balance in relation to the standard of play, the comfort and convenience of players, and the demands of economic maintenance.

The endeavour here made is therefore to set out the main principles governing the selection of land for playing fields, average dimensional requirements and marginal clearances for the most popular games in the British Isles, various factors influencing the siting of facilities and amenities, basic constructional requirements, and the broader aspects of management and maintenance. In addition some suggestive draft specifications for the

construction of different types of games pitches and courts have been included, as well as some notes on floodlighting for late evening play. It is hoped this information, not hitherto available, will be useful in saving time and effort on the part of all who may be called upon to prepare schemes for the establishment of playing fields, and ensure greater efficiency in planning and construction.

The book has been prepared under great difficulties during such periods as could be spared without seriously impairing the normal routine advisory work of the department, which has been considerably increased since the close of the war through pressing demands for guidance not only in relation to new projects, but in respect of the restoration of numerous established playing fields allowed to deteriorate through lack of maintenance during the war years, or which had been put out of commission completely by military occupation or conversion to agricultural purposes under compulsory orders. The volume of inquiries has severely taxed the limited technical resources of the Association and the reader will perhaps make due allowance for any shortcomings in the manner of presentation. The subject is vast and complex and its treatment must of necessity be restricted to those matters on which our advice is most frequently sought.

It will be noted that no serious consideration has been given to arrangements for the accommodation of spectators. The Association's concern is not with sport as a spectacle, or as a financial proposition. Its purpose is mainly to ensure that as far as practicable all who desire to play games shall be provided with the necessary facilities to do so with reasonable proficiency.

Similarly, no attempt has been made to deal with the technical aspects of surveying, levelling, setting out, bills of quantities, and other preliminary works of which it is assumed the reader has already ample knowledge. It has also been considered that as eminent specialists have already covered such subjects as Soil Management, Weeds, Grasses, Insect Pests, and Diseases in relation to their influence on the establishment of sports turf, there is no need to go over the same ground. For those who would like to pursue a more intensive study of these branches of science a short bibliography is included.

The author is greatly indebted to Sir George Pepler, C.B., PP.T.P.I., F.R.I.C.S., the Chairman of the Grounds and Layout Committee of the National Playing Fields Association, for reading over the manuscript and

offering many valuable suggestions and constructive criticisms which have helped considerably in improving the text.

Sincere thanks are also due to his deputy, Mr. R. B. Gooch, A.F.S. (Eng.), and to his assistant, Mr. L. Oxborrow, for their work in preparing the plans and diagrams used for illustrations. Acknowledgements have been made in the text to those specialist manufacturing or contracting firms who have kindly furnished photographs of interesting machines, appliances, or work in progress. Their help in these matters has been highly appreciated.

P. W. S.

1949

IMPORTANT NOTE

Since the preparation of the manuscript a critical situation has developed in relation to the importation of grass seeds and the supply of several important varieties is likely to be difficult for many years to come. Accordingly, the greatest economy must be exercised in relation to the seeding of playing areas of all types.

Whatever may be the opinions of specialist constructors, the generous pre-war rates of seeding referred to in the text cannot be justified in present circumstances. Seeding rates for cricket outfields and other larger pitches for football, hockey, and similar games should not exceed 1 cwt. per acre. Bowling greens, tennis lawns, and similar fine-turf areas should be sown at rates not exceeding ¾ to 1 oz. per square yard.

These lighter seeding rates will demand the utmost care in preparation and pre-treatment of the soil, and accuracy in broadcasting to secure uniform cover. Optimum climatic conditions during the operations are, of course, essential to ensure maximum germination, and a longer period may have to be allowed for the sward to become established.

1950

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THE author expresses his sincere thanks to the undernoted for the illustrations used in the text.

Messrs. Blaw-Knox, Ltd., Clifton House, Euston Road, London, N.W. 1.
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I

CHOOSING A SITE

It is possible to adapt almost any piece of land of adequate dimensions to playing field purposes, but it may not always be economically practicable. Constructional and maintenance costs are generally the main factors in determining the extent to which playing facilities may be developed on any particular site, and it is therefore essential that before acquiring land for a playing field, due consideration should be given to its adequacy, suitability for economic development and maintenance, accessibility, and relationship to any general planning proposals of the district.

Area required. The recommendation of The National Playing Fields Association in relation to the space required to meet reasonably the needs of the population for playing facilities has been recently revised and re-stated in the light of an experience extending well over twenty years. The original standard of playing space laid down by the Association was not less than 6 acres per thousand of population, which might include up to 2 acres per thousand of population of permanently preserved privately owned land developed as playing fields for the use of sports clubs, the welfare sections of industrial or commercial organizations, or schools and other educational establishments.

Thus the area required for publicly owned and permanently preserved playing space in any district might be anything from 4 to 6 acres according to the extent to which permanently preserved sectional or private interests had been met.

It became evident, however, that many private grounds belonging to industrial or educational establishments often catered for sections of the population far removed from the district in which the field is situated, and that, owing to risk of overplay, rapid deterioration, and maintenance difficulties, few private clubs or organizations could afford to offer their facilities for public play even during those periods when not in private use. Accordingly, such private grounds did little to relieve the pressure on public playing space, and the Association now thinks it unwise to take them into consideration in determining the amount of land that should be reserved for public playing fields.

The Association, therefore, now recommends that to ensure adequate

communal playing facilities *a minimum of 6 acres of publicly owned and permanently preserved playing fields per thousand of the population is essential. This 6 acres per thousand must be exclusive of any privately owned sports facilities, woodlands, commons, pleasure grounds, ornamental gardens, or other open spaces where the playing of games by the general public is neither encouraged nor permitted.* It should also be understood that in using this basis for the determination of the playing space required by any community, full-length nine-, or eighteen-hole golf courses should not be included, although the more popular putting greens and miniature golf courses of the pitch and putt type may be reckoned where their provision absorbs only a reasonably small fraction of the aggregate playing space required.

In applying these minimum standards, the Association realizes that in many circumstances they must be increased. For example, 6 acres of suitable shape and dimensions is just about the minimum area required to provide space for senior football, hockey, cricket, and some limited allowance for tennis, bowls, and children's corner. Accordingly, even where the population of a village or parish is less than a thousand and yet it is felt that all the usual games facilities for adults and children are desirable, it must be obvious that to reduce the acreage to less than 6 would make it impossible to achieve an adequate development. Or, again, where the population of a rural district or parish is generally dispersed among widely scattered villages or hamlets, it may be difficult to provide facilities on one field conveniently situated to the homes of all who desire to play. It is clear, therefore, that in deciding the extent and disposition of playing fields for any district, this should not be determined solely in relation to the population figures, but consideration must also be given to the density of distribution, transport facilities, and other local factors affecting the convenience of users.

Anticipating future requirements. In districts where an appreciable increase of population is likely through housing development plans, future requirements in relation to playing space should be taken into account in determining the area of land to be acquired. Any land acquired which is surplus to immediate requirements, can be let out for grazing or other temporary purpose, which will not prejudice its economic adaptation to sports purposes, until such time as the complete development of the playing field can be undertaken. The financial proceeds from such lettings may be devoted to assisting the maintenance of any facilities already provided.

Powers to acquire in excess of immediate requirements. Local authorities can, with the consent of the Ministry of Health, acquire more land than is imme-

diately required or than can, at the time of acquisition, be conveniently fully developed. Section 5 of the Town and Country Planning Act, 1947, enables Planning Authorities to designate land, in their development plans, for playing fields. Land so designated would be ultimately acquired by the District Council concerned, using compulsory powers if necessary. In designating sites for playing fields, Planning Authorities should look at least seven years ahead, bearing in mind that designations can be renewed where any revision of plans makes it advisable.

Location. A playing field should be situated, wherever practicable, as near as possible to the centre of the built-up area so that it may be within easy reach of all possible users. Even in newly planned districts, however, the playing field is far too often the last amenity to receive consideration in the general planning scheme. Consequently, after the building plots have been set out in accordance with the predetermined density per acre, any space remaining and considered unsuitable for building development is allocated for recreational purposes, no matter how awkward its shape, proportions, contours, and other aspects may be to the economic planning and establishment of the essential playing facilities. Surely it must be conceded that houses alone, however well conceived and constructed, can never provide happy and healthy homes for the masses of our people without reasonable amenities for social and recreational activities. The importance of adequate playing facilities to the health and contentment of the community is now generally accepted and should be sufficient grounds for ensuring their primary consideration in the planning of all new townships and residential areas. Only where this is done will it be possible to locate the playing field on a site offering the maximum scope for economic development and reasonably accessible by all sections of the community. It is encouraging to learn that a number of Planning Authorities have in mind as an important feature of their Development Plans an integrated system of open spaces in which playing fields will have their rightful place.

Road frontage, except for the purpose of providing access, may not be essential to a playing field. If not too expensive a luxury, however, by way of road charges, it does improve the general amenities of the locality and allows a greater freedom in the siting of entrances to suit both the convenience of residents and the efficient internal planning of the field. It also permits a greater latitude for connexions to any public service mains where these exist under the roadway. On the other hand, where residential property backs on to the playing field on all sides, reasonably convenient access for all

residents may not be easy to arrange, and opportunities for connexions to public services may be greatly limited. Where such backland playing fields are extensive in area and further entrances have to be arranged, it may result in the necessity to provide footpaths to link up these entrances to save unnecessary traffic on the playing areas. Such provision, of course, must seriously curtail the area available for games. Wherever practicable the number of entrances should be reduced to the minimum necessary for convenient access to the various facilities provided, and they should be so situated or arranged as to discourage pedestrians from making short cuts across the main turf area with the consequent risk of forming unsightly tracks.

Shape and dimensions. As the majority of games are played on rectangular pitches or courts, it follows that to plan for maximum development with the minimum of waste space a field as nearly rectangular in shape as possible, if suitably proportioned, will be best. Acute and obtuse angles and irregular boundaries involve waste of space. So do salients unless they are large enough for development as children's corners, car parks, tennis courts, bowling greens, or similar features. Where fields have been acquired with irregular boundaries every effort should be made to effect an appropriate rectification by 'give and take' exchange of land with the adjoining owners. Acquisition or exchange of land to provide a more convenient access may also have to be considered in some cases.

It must be emphasized that the facilities which may be conveniently accommodated in a field of any given acreage can only be determined when the shape and dimensions are known. This somewhat elementary fact is stated because we are so frequently asked 'What recreational facilities can we provide in a six-acre field?' or questions of a similar nature. It is of course possible to have a field of extensive area but of such narrow width that the provision of any standard games facilities is quite impossible. The minimum dimensions for any field where it is desired to accommodate comfortably senior football and cricket, should not be less than 130 yards long and 170 yards wide, and the general orientation should be between north-west to south-east and north-north-east to south-south-west.

Effect of district planning proposals. It is important that, before proceeding with the acquisition of any land for the purpose of playing field development, the planning authority for the district should be consulted so that it may be known whether or not such development will conform with their proposals for the area concerned, and that the field is, or can be, scheduled accordingly for permanent preservation as an open space. If this is in order,

the implications of any contiguous or adjacent development should be carefully studied in respect of such matters as possible encroachment for future road-widening schemes, wayleave concessions for sewers, water, or other public service mains, as allowances for any such contingencies may adversely affect the planning of the field by seriously restricting the possible uses of the available space.

In this connexion also, the existence of other obstacles to the full development of the site must be investigated. There may be existing underground sewers, service mains, or electric cables to be taken into account. If these are of sufficient depth to be unaffected appreciably by any surface adjustment or not to obstruct any drainage provisions necessary for the establishment of playing facilities, and are of such a nature that the possibility of frequent opening up is remote, then there may be no objection to the layout of a general grass area for team games over them, provided that any surface manhole covers can be lowered to at least 12 inches below finished turf level. Every endeavour however, should be made if space will allow, to keep such underground services clear of the actual playing pitches wherever practicable and certainly in no circumstances should costly features such as bowling greens, tennis courts, and the like be sited over any underground structures of this nature.

Freedom to remove or lop any trees situated on the field or overhanging the boundaries is also essential to effective planning in many cases, and the possibility of diverting any existing right of way, electric pylons and overhead cables or telephone wires must be fully explored before the maximum development can be determined.

Flooding. The area should be immune from flooding or capable of being made so by protective embankments or similar means. In this connexion it must be emphasized that any flood-control measures contemplated should have the approval of the proper Drainage or Catchment Board responsible for the area concerned, otherwise conditions may be aggravated on adjoining lands or along the opposite bank of the river or stream.

There are occasions, however, where no other suitable land is available and where the flooding is not normally of long duration, when excellent playing facilities might be provided within the limits imposed by such periodic restrictions on play. In such cases development should be confined to turf areas for football, hockey, cricket, or grass tennis which are not seriously or permanently affected by occasional flooding, provided play does not take place before the ground has dried out sufficiently.

Such facilities as hard tennis courts, bowling greens, or children's playgrounds should not, of course, be sited on fields where there is any danger of their submergence during flooding.

Surface configuration and soil characteristics. It is, of course, a great advantage if the field is sufficiently level to obviate the necessity for major levelling or extensive surface regulation, as distinct from any minor localized adjustments. It would also be folly to lay down hard and fast rules as to maximum permissible gradients whose attainment might be impossible in many districts on economic grounds. It is desirable wherever possible that the gradient should not exceed 1 in 50 where a reasonable standard of play is to be expected without undue fatigue. There are many hilly districts, however, where no reasonably level land is available and where the possibility of encountering rock at shallow depths precludes any major improvement for financial reasons. In such circumstances much steeper gradients than would normally be advised have to be accepted and cases are known to us where clubs have functioned on pitches with gradients approaching 1 in 15 rather than be deprived of facilities for their favourite team game. In such cases, however, the main direction of play must be transverse to the general fall of the land, and this practice should be followed wherever the surface gradient exceeds 1 in 50. Gradients exceeding 1 in 30 are not recommended.

A field already covered with a good pasture turf, reasonably level, and clear of any obstructions, can be readily made use of for sports purposes at comparatively slight cost and is therefore to be preferred, especially where the demand for team games is urgent. Any type of soil, however, may be adapted to the establishment of a good sports turf surface, the only limiting factor being the financial resources available. For the most economic results on arable land there should be from 6 to 8 inches of good light loam free from large stones as surface soil, overlying a fairly permeable subsoil so that expenditure on subsoil drainage may be avoided, or if required, reduced to a minimum.

Comparative values of alternative sites. It will be evident, therefore, that the relative economic values of alternative sites for development as playing fields cannot be judged solely by a comparison of the costs of acquisition. The more costly land to acquire may be capable of conversion with much less constructional effort than the cheaper land. It is therefore essential before a decision is reached that the comparative values of all possible sites should be carefully assessed in relation to:

1. Cost of acquisition.
2. Cost of development and equipment.
3. Cost of maintenance.
4. Proximity to the main centre of population, or convenient means of access for those likely to use the ground.
5. Capacity to meet immediate and future requirements.

There are, of course, few areas which fulfil all the desiderata for a playing field. The scope of selection is at best usually limited to a few sites to each of which different advantages are attached. The problem therefore resolves itself into giving the proper weight to the pros and cons in each case in order to determine which site offers the most attractive possibilities for development both from the playing and economic aspects.

City and urban areas. It is, of course, fully appreciated that in old-established, densely built-up industrial and urban areas it is too often quite impossible to find any adequate ground centrally situated to meet the needs of the community for games facilities. Consequently the only suitable land must be sought on the fringes of the town or just beyond the boundaries. Normally, however, there are reasonable and cheap transport facilities in these areas and therefore distance does not seriously inconvenience adult players, whose visits to the field are generally of some duration. In the case of children, however, if suitably safe and attractive alternatives to playing in the roads are to be provided, then obviously these must be situated within reasonable distance of their homes otherwise they will be of little value to youngsters paying frequent short visits.

The latter difficulty can sometimes be met by acquiring small centrally situated areas, as may be practicable to suit the distribution of the child population, for development solely as children's playing-grounds. Undeveloped backland plots of a quarter of an acre or even less, according to the number of children, can often be readily adapted to such purposes, provided there is a convenient access. Where the area can be increased to include in addition a suitable dry surface playground, say 70 by 45 yards, a considerable easement in the difficulty of providing 'organized games' facilities may be accomplished.

The floodlighting of these play-areas for children, where it can be afforded, will greatly increase their attraction during the early hours of the long winter evenings when the dangers of the highway for children are intensified. The ideal arrangement would be to have suitable play-areas so situated that no

child would have to walk farther than a quarter of a mile to find one, and in doing so need not cross any main traffic thoroughfare. It is realized this will not always be possible, but the nearer we can approach to these suggestions the safer will become the playtime activities of our young children.

Advantages of separate play-areas for children. Where separate arrangements can be made for young children's playing facilities, it will naturally widen the scope of choice for the location of the main playing field even in rural districts. A much greater latitude may be exercised in relation to distance from the centre of population, provided, of course, reasonable transport facilities are available. There will also be much greater freedom in arranging the adult games pitches without the restrictions that must of necessity be imposed where the interests of children are concerned.

II

SPACE REQUIREMENTS FOR GAMES AND ATHLETICS

THE diagrams and tables introduced here are intended to indicate at a glance the desirable range of dimensions for various games pitches and courts recommended for general use on public playing fields. It must be obvious that to adhere strictly to international standards for the dimensions of public games pitches entails such an extravagant use of space that the number of facilities which could be accommodated on the field would be considerably reduced and consequently many more would have to be denied opportunities for play than would be necessary where less generous allocations are planned. Quite apart from this, however, the player who has to depend on public facilities has not, as a rule, much time for the intensive training such as the professional player enjoys. His or her physical recreation has to be taken during such leisure hours as may be spared, often after a strenuous day's work, and therefore playing on pitches of the largest dimensions would result probably in rapid fatigue and overstrain, which would be neither good for the player nor the game itself.

On the other hand, there are limits to the reduction in playing-areas if a reasonable standard of proficiency and enjoyment is to be attained by the players. Furthermore, unduly cramped conditions naturally tend to concentrate the traffic more severely during play, resulting in much more rapid wear on the playing-surface and a consequent aggravation of the complex problems of management and maintenance.

The maximum dimensions recommended here are those adopted by many clubs engaged in first-class competitions and may therefore be accepted as adequate for all senior players desiring public facilities. The lower dimensions recommended for junior and other grades of players are those in fairly general use throughout Great Britain.

Marginal clearances indicated should be considered as minima to avoid excessive interruption by play on adjoining pitches and also to provide space for circulation for a limited number who may wish to watch the games. Where pitches are adjacent to the boundaries of the ground it is advisable to increase the marginal clearance on the boundary side or end by a further 10 feet, provided that in so doing the facilities that can be accommodated

are not diminished in number nor restricted in area to any appreciable extent.

Association Football. (See diagram Fig. 1.)

PLAY-GROUP	LENGTH 'L'	WIDTH 'W'	MARGINAL CLEARANCES	
			SIDES	ENDS
	yards	*yards*	*ft. in.*	*ft. in.*
Seniors	105–110	65–70	20 0	30 0
Juniors	100	50–60	20 0	30 0
Schools				
Pupils aged:				
14–16 years	100	50–60	15 0	20 0
12–14 „	80	50	15 0	20 0
10–12 „	60–70	40–45	10 0	15 0

Note. Some educational booklets suggest 100 by 70 yards as the size of the main association football pitches for boys 14 to 16 years old, but this width is frequently adopted by first-league clubs with a length of 110 yards and is therefore out of proportion to the length specified. Sixty yards width is definitely a more suitable maximum for schoolboys.

Rugby Football. (See diagram Fig. 2.)

PLAY-GROUP	LENGTH 'L'	IN-GOAL 'K'	WIDTH 'W'	MARGINAL CLEARANCES SIDES AND ENDS
	yards	*yards*	*yards*	*ft. in.*
Seniors	105–110	10–15	70–75	20 0
Juniors	100–105	10	65–70	20 0
Schools				
Pupils aged:				
14–16 years	100	10	60–65	15 0
under 14 years	80–90	7	55–60	15 0

Hockey. (See diagram Fig. 3.)

PLAY-GROUP	LENGTH 'L'	WIDTH 'W'	MARGINAL CLEARANCES	
			SIDES	ENDS
	yards	*yards*	*ft. in.*	*ft. in.*
Men	100	55–60	10 0	15 0
Women	90–100	55–60	10 0	15 0
Juniors	90	55	10 0	15 0
Schools				
Pupils aged:				
14–16 years	90	55	10 0	15 0
under 14 years	80	50	10 0	15 0

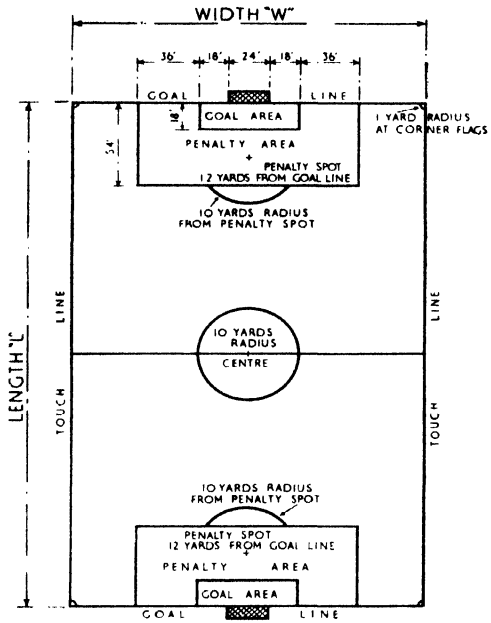


FIG. 1. ASSOCIATION FOOTBALL

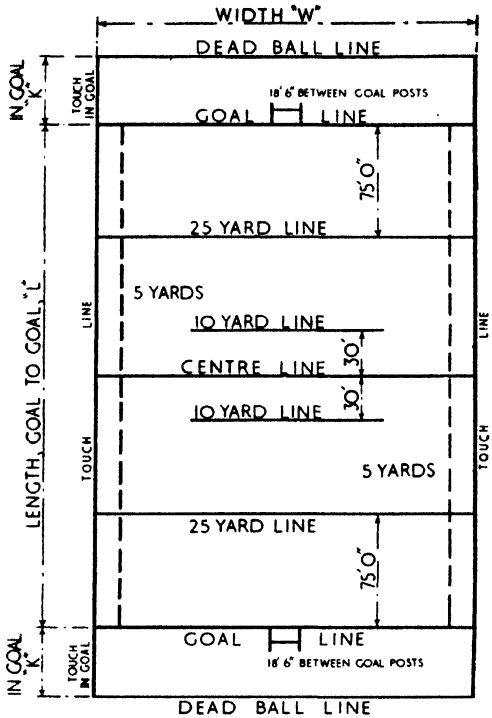


FIG. 2. RUGBY FOOTBALL

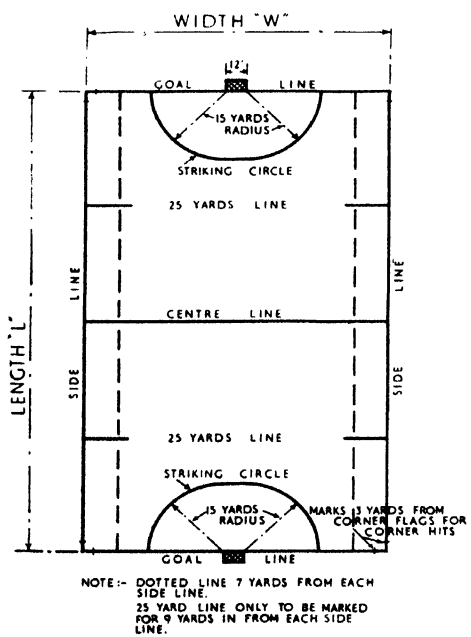


FIG. 3. HOCKEY

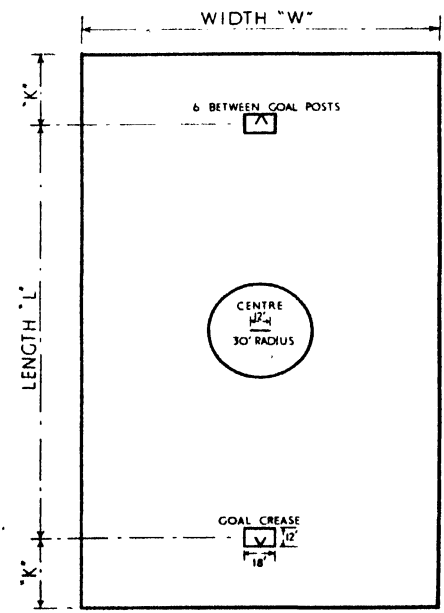


FIG. 4. LACROSSE

Lacrosse. (See diagram Fig. 4.)

The English Lacrosse Association lay down no definite over-all dimensions for pitches. The boundaries of the field of play are left for agreement by the captains of opposing teams. It is, however, stipulated that the goals shall not be less than 90 yards or more than 110 yards apart. The maximum dimensions that might be allocated on public playing fields in Britain, when there is a demand for such facilities, should not exceed the overall dimensions of a senior rugby field. Otherwise it will be difficult to encourage any increase in popularity on account of the excessive demands on space available.

PLAY-GROUP	BETWEEN GOALS 'L'	BEHIND GOALS 'K'	WIDTH 'W'	MARGINS ALL ROUND
	yards	*feet*	*yards*	*feet*
Adults	90	45	70	10
Schools				
Pupils aged:				
14–16 years	80	30	60	10
under 14 years	70	30	55	10

Cricket. (See diagram Fig. 5.)

The most common dimensions for the cricket table providing the wicket area on public playing fields are 90 by 90 feet. Widths less than 60 feet and lengths less than 75 feet cannot be recommended.

The method of determining the outfield limits are clearly indicated on the diagram. The double lines near the ends of the table represent the lines on which the bowling creases and popping creases would be marked; the bowling creases being 66 feet apart and the popping creases 4 feet in from each bowling crease. A reasonably safe boundary for senior cricket would be 50 yards radius from the centre stump at either end of the wicket in whatever position they may be pitched on the table. The outfield allowance is accordingly decided by setting out a quadrant with a radius of 50 yards from each point where the bowling crease meets the edge of the table and joining up in the manner shown. For junior cricket, a minimum radius of 40 yards is recommended. Thirty yards radius would in most cases be adequate for boys under 14, the wicket being reduced in length to 18 yards.

Where, however, the boundary is adjacent to a public highway, glasshouse, or buildings with windows, the boundary allowances should be increased at these points by at least 10 yards.

Areas devoted to cricket alone are, of course, extravagant in the use of space and can seldom be justified on public playing fields. The usual practice is to site winter games pitches in the outfield as indicated on the diagram, the additional area required to arrange this greatly increasing the uses which can be made of the field for sports purposes.

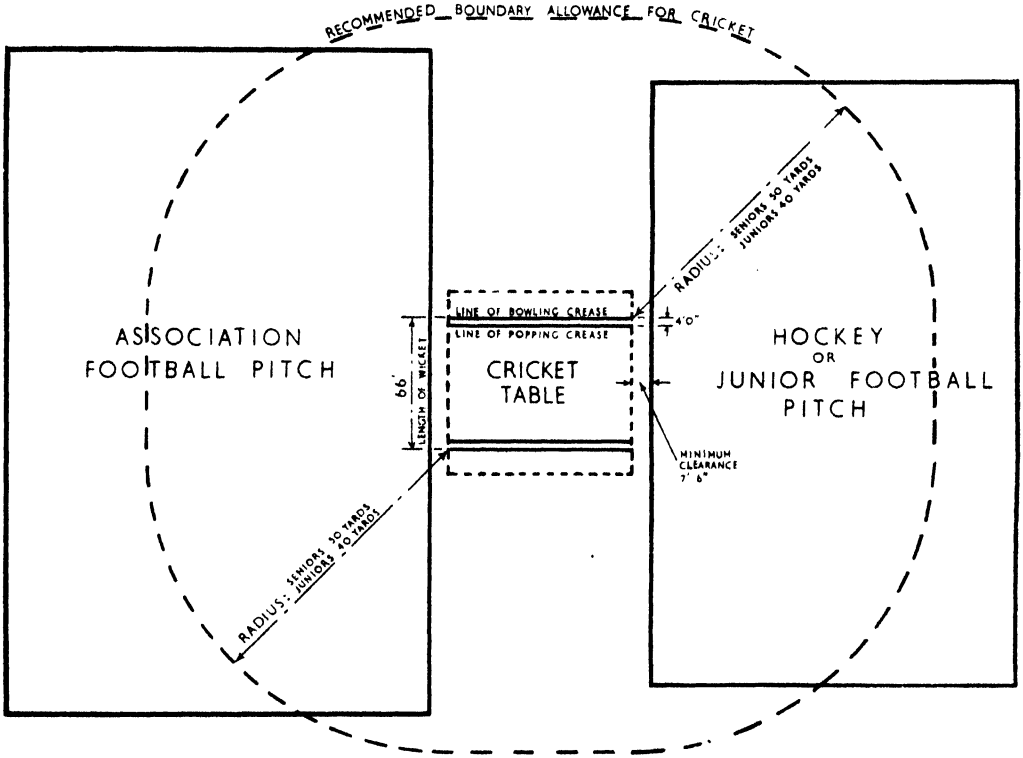


FIG. 5. CRICKET

For example—a 90-foot square cricket table with sufficient ground to provide the outfield for senior cricket only, would require an area of approximately 3·6 acres, whereas the same table with a senior football pitch, 110 by 70 yards on one side, and a hockey or junior football pitch, 100 by 60 yards, on the other, would require approximately 4·8 acres. By increasing the area therefore by one-third, a much more varied use can be made of the field without any appreciable detriment to any of the facilities provided.

Marginal clearances between the edge of cricket tables and touch-lines

of adjacent winter games pitches should be from 7 ft. 6 in. to 10 feet, to allow space for circulation when tables are roped off for treatment in winter.

It is understood, of course, that on many small village grounds, space cannot be afforded for an independent cricket table without severely restricting the use of the ground for winter sports. In such circumstances, a suitable wicket area has to be prepared after winter play has ceased. This means that the seasons for winter and summer games would have to be curtailed to allow reasonable time for remedial work to be carried out as may be necessary on the much overplayed cricket table area. Such arrangements should be tolerated only where there is no alternative.

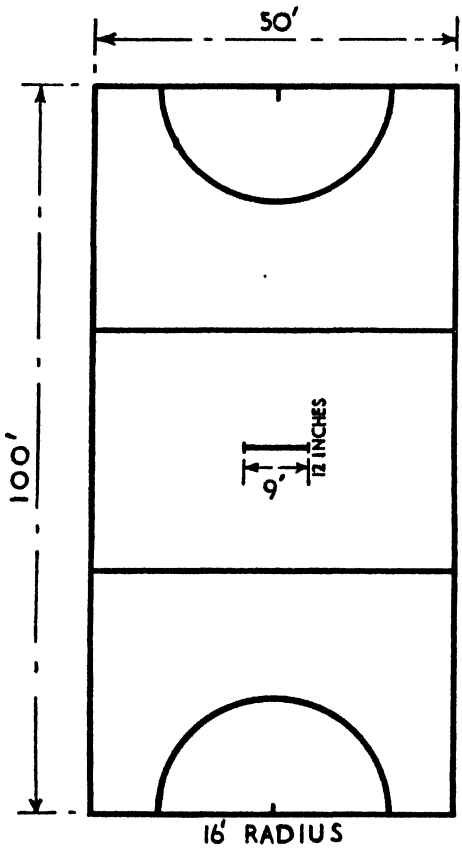


FIG. 6. NETBALL

Cricket practice. Wherever space will permit, a site should be reserved on some convenient part of the outfield for cricket practice wickets. The position should be well clear of the cricket boundary so that the nets can be left up in suitable weather without interfering with match play. A width of 15 feet per wicket, with a length of 75 to 90 feet is a reasonable allowance. A space 90 by 90 feet would provide for six practice wickets side by side with division nets between.

Netball. (See diagram Fig. 6.)

The diagram shows the standard marking for netball courts. Dimensions are 100 feet long by 50 feet wide and marginal clearance should not be less than 6 feet all round if separately enclosed. Where, however, several courts are sited side by side, or courts adjoin a boundary, the margins should be increased to 10 feet.

Tennis. (See diagram Fig. 7.)

Over-all length 'L'. Over-all width 'W'. Additional width for each further court in same enclosure 'A'. Side-shifting allowance 's'.

TYPE OF COURT	PLAY-GROUP	'L'	'W'	'A'	's'
		ft.	*ft.*	*ft.*	*ft.*
Hard	Tournament	120–130	60–65	48–50½	..
Hard	Public	114	56	46	..
Hard	Schools	108	52	44	..
Grass	Tournament	120	60	48	24
Grass	Public	110	56	46	23
Grass	Schools	106	52	44	22

Note. It is an advantage on grass courts if an allowance can be made for moving the courts when the centre of the base lines begin to show signs of wear. This amount should equal half the width over the playing lines plus half the interval between the courts or the side margin. This arrangement is only possible where movable tennis post sockets are used. Where sockets are fixed in concrete, such movement is impracticable unless an extra pair of sockets can be set for the alternative positions.

Tournament dimensions as shown in the table are rarely required on average public playing fields except in some larger communities where it is proposed to stage championship or international tournaments, in which case special accommodation for spectators would be desirable. Such arrangements do not come within the scope of this book.

For normal public tennis facilities the second set of dimensions for each type of court have proved adequate and need not be exceeded. Where courts are provided mainly for use by schools a reduction in the run-back and side-run allowance is very desirable, and the dimensions indicated would be suitable for most players under 16 years of age. This scaling-down of over-all dimensions to suit the type of player not only reduces fatigue, but results in an appreciable saving in cost of construction and maintenance on account of the smaller superficial area required, especially where several courts are being provided.

The clearance margins required beyond the stop-netting enclosure will, of course, be dependent on the type of surrounds favoured. Sometimes a footpath with occasional seats is provided round the enclosure where friends of players or other interested spectators may view the games in comfort. This allowance, where it can be afforded, is also useful in isolating

the tennis courts from the more general games areas and saves much laborious efforts on the part of the ground staff in trying to keep the edges tidy and free from weed infection. Where the field area is allowed to run right up to the stop netting it can become a serious nuisance in this respect.

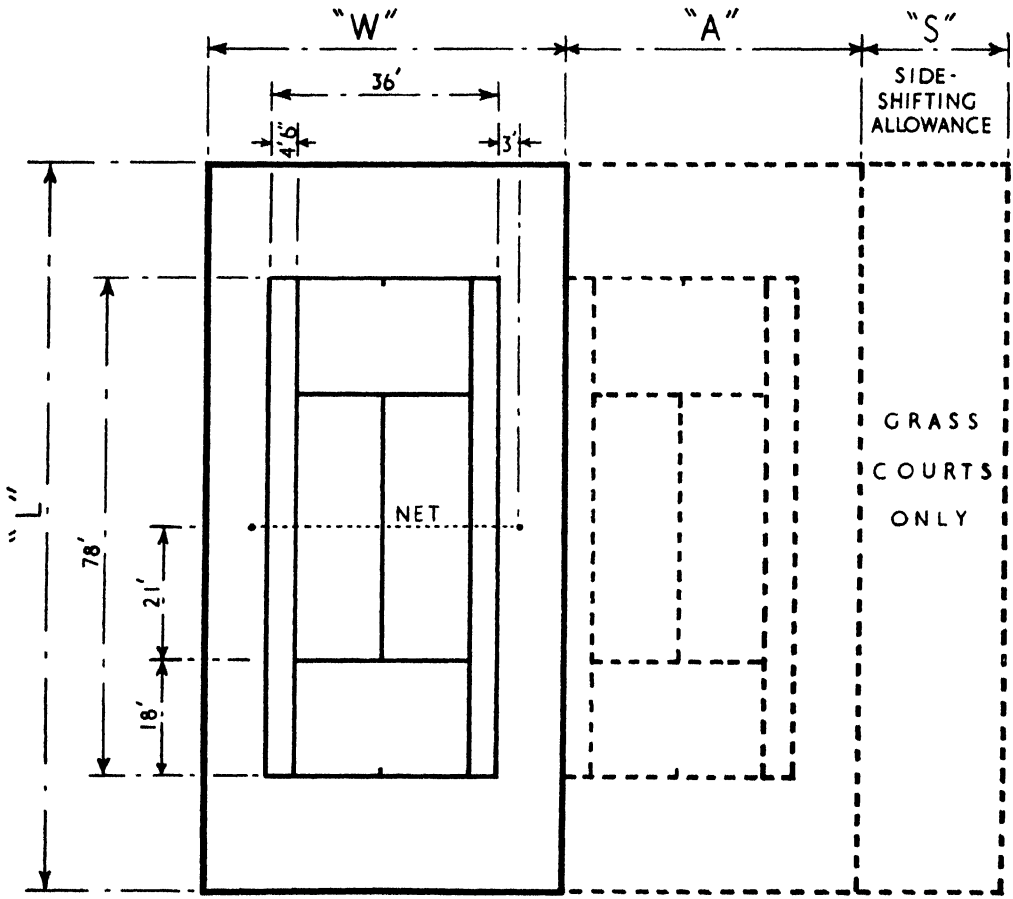


FIG. 7. TENNIS

Allowance must also be made where the site has to be levelled for tailing out the limits of the cut-and-fill to a suitably stable batter.

It is an advantage to provide a good evergreen hedge or a narrow border of suitable shrubs round the courts as a background and wind-break, and also to avoid distraction caused by the movement, across the line of vision, of players on other sections of the playing field.

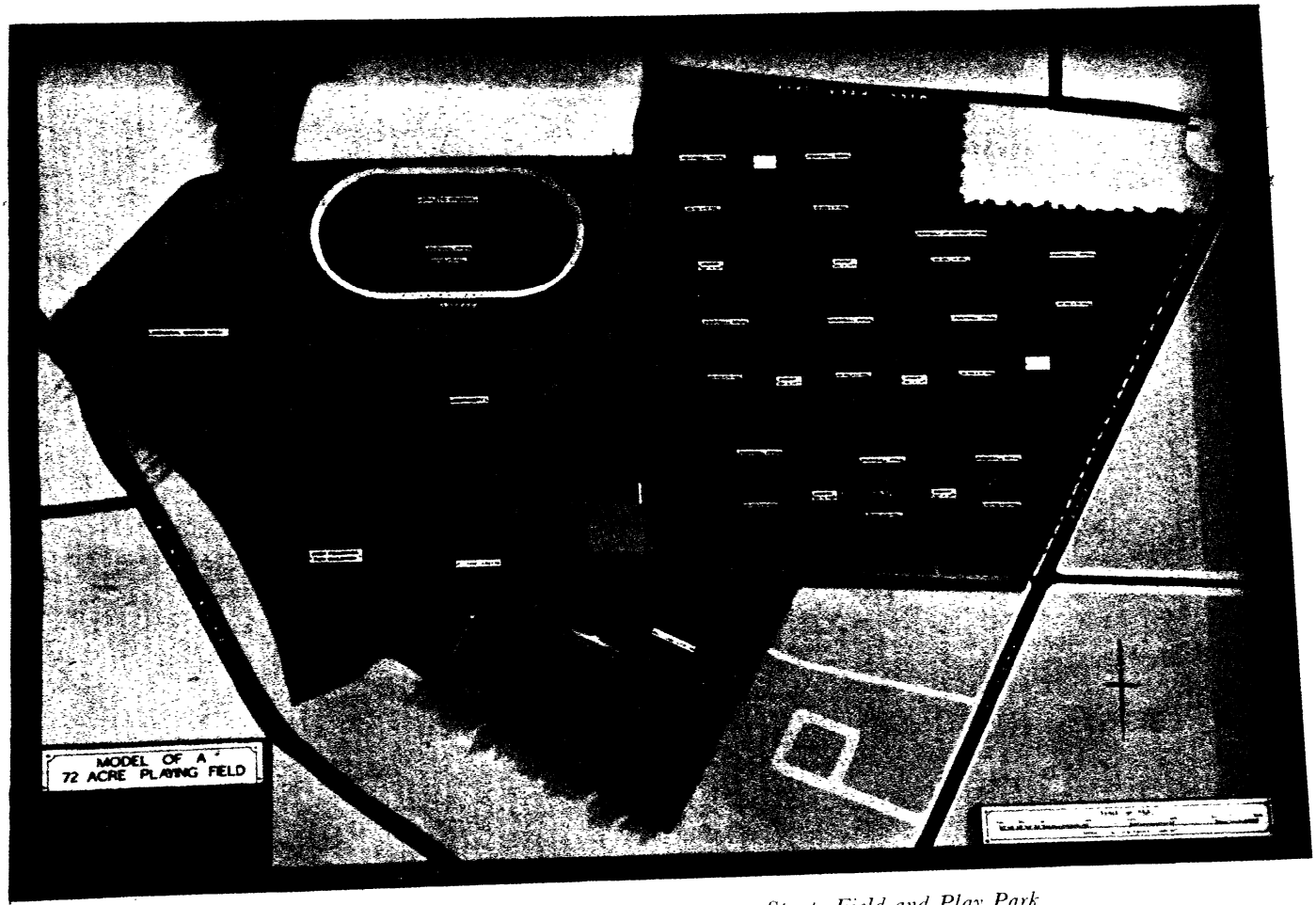


PLATE I. *Photograph of model for a 72-acre Sports Field and Play Park*

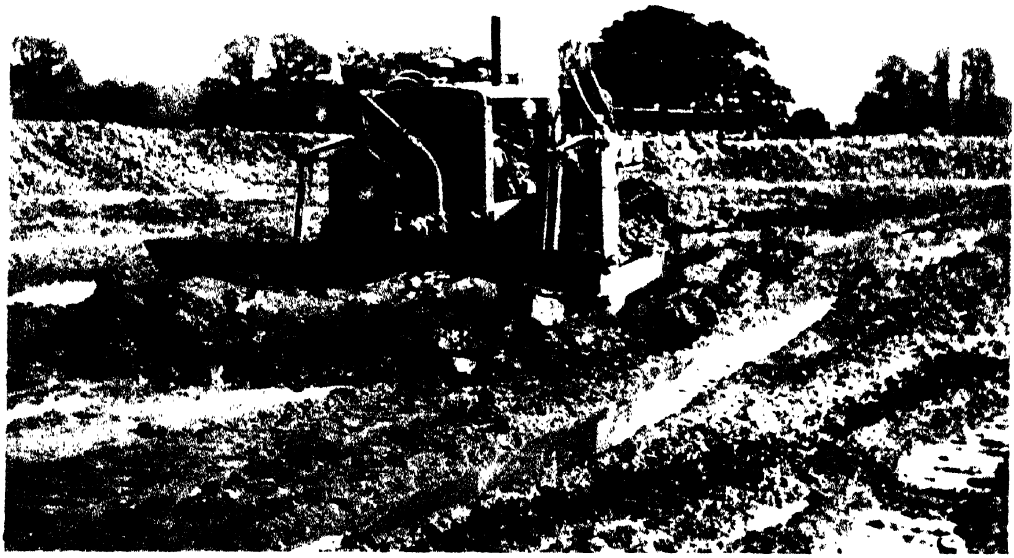


PLATE 2. *'Caterpillar' D.6. Crawler Tractor with Angle-dozer. Note how readily soil is puddled when work is carried out in saturated conditions*

PLATE 3. *'Cletrac' Crawler Tractor and Bull-dozer engaged on levelling*

Bowling Greens (Rink Bowls; Flat Green). (See diagram Fig. 8.)

Although the International Bowling Board state a minimum length of 33 yards and a maximum of 44 yards with rink widths of from 19 to 21 feet, few county associations favour lengths of less than 40 yards. Normal full-size dimensions in England, 42 yards square.

Full-size square greens allow the direction of play to be varied transversely from time to time, thereby reducing the wear on the edges of the green. For smaller communities, however, full-size greens may be too large for their requirements or for the space available and accordingly they may have to be satisfied with greens of two, three, or four rinks in width. In such cases, as the direction of play cannot be varied, an additional half-rink in width should be allowed, wherever possible, so that the position of rinks may be moved slightly sideways from time to time to distribute more evenly the effects of traffic on the ends of the green.

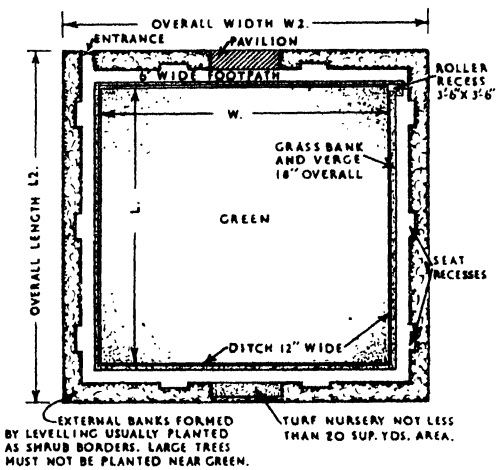


FIG. 8. BOWLING GREEN

The undernoted dimensions are recommended wherever practicable:

GREEN WIDTH	W.		L.	W. 2.		L. 2.
	ft.	*in.*	*ft.*	*ft.*	*in.*	*ft.*
2 Rinks	52	6	126	86	6	160
3 Rinks	73	6	126	107	6	160
4 Rinks	94	6	126	128	6	160
5 Rinks	115	6	126	149	6	160
6 Rinks	126	0	126	160	0	160

The diagram shows a typical arrangement of green and surrounds. Whatever the size may be, a footpath round four sides will help in preventing unnecessary pedestrian traffic on the playing area. The batters formed by the levelling of the green surrounds are usually planted as borders of evergreen shrubs to provide a pleasing background and wind-break. A good hedge or border may also be useful in checking to some extent windborne weed-seeds from reaching the green.

Crown Bowls

In this game, play may take place in any direction the players may choose, therefore square greens are best. Usual dimensions are 40 by 40 yards, the surface being finished to a camber with a 10-inch rise at the centre

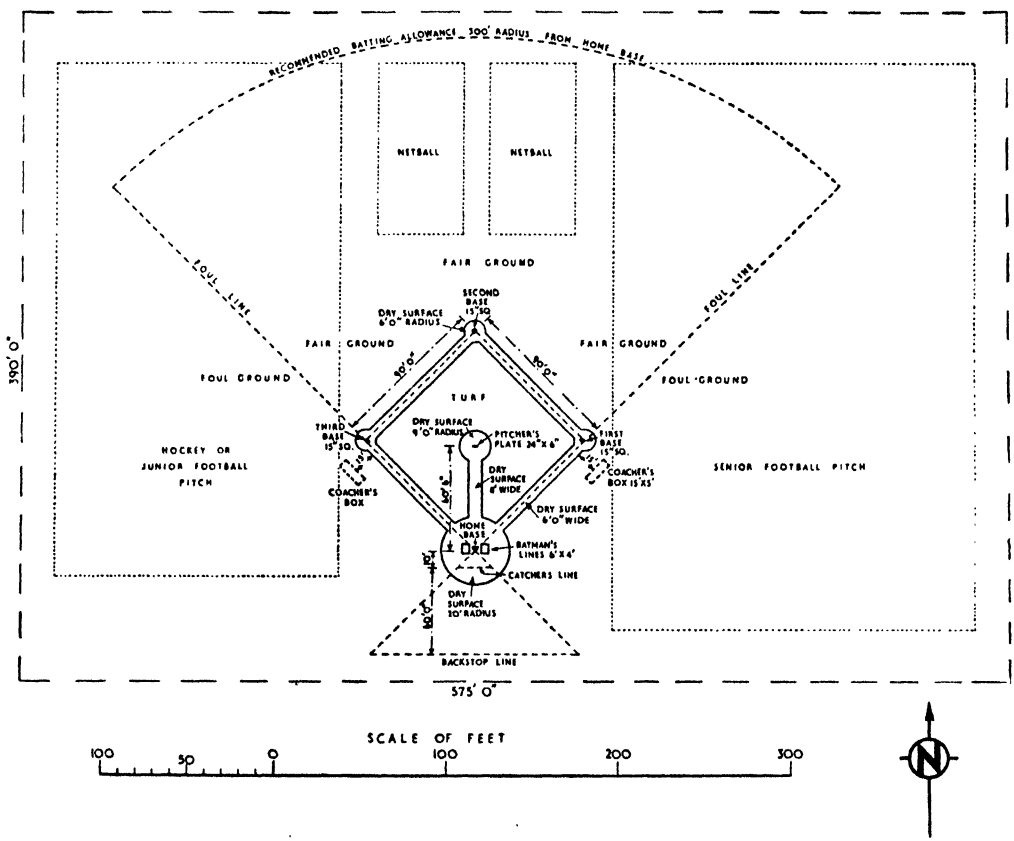


FIG. 9. BASEBALL

To accommodate winter games in the outfield a space allowance should be made of approx. 5 acres

above the levels at the corners. Ground space required will be from 45 to 50 yards square, according to the width of surrounding walks and borders, or the amount necessary for marrying the finished levels with the surrounding contours.

Baseball

This American game is becoming increasingly popular in certain parts of Great Britain, and there may be on occasions a demand for facilities on

public playing fields. The space requirements are indicated on diagram Fig. 9. Where only occasional and infrequent play is anticipated, the diamond can be marked out on the turf as and when required, but when regular use is assured, it is better to provide a suitable all-weather surface which will offer a higher resistance to the concentrated traffic of play on this

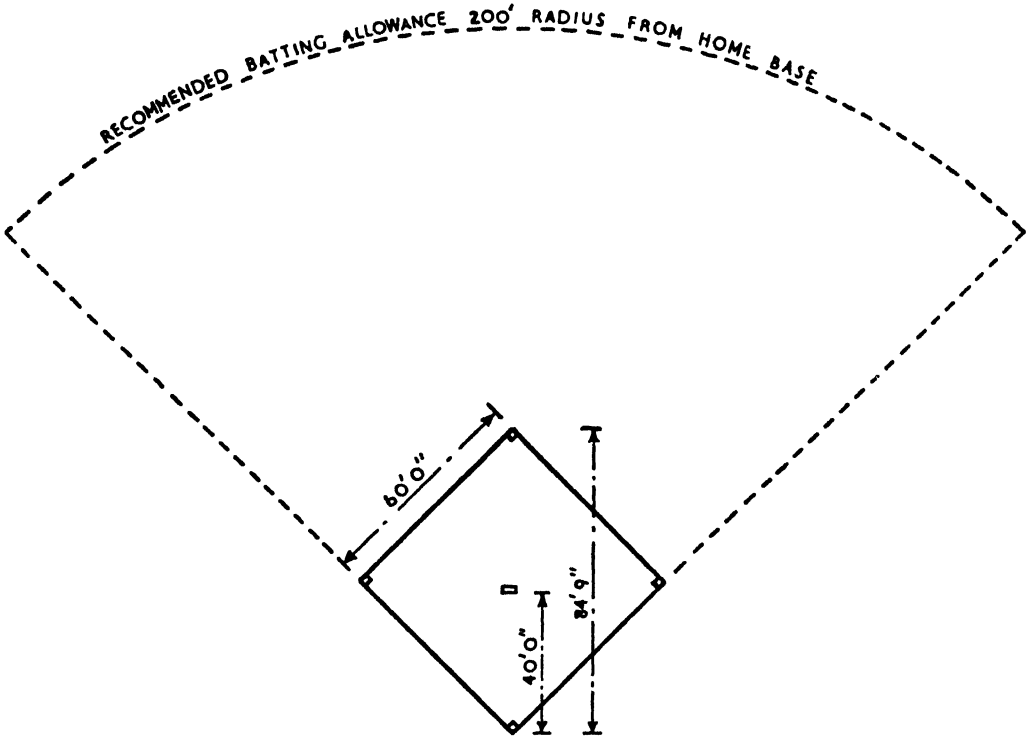


FIG. 10. SOFTBALL

section of the field. A cinder-track surface with or without an approved crushed-stone finish would be excellent for the purpose.

If permanent facilities for baseball are to be provided between winter-games pitches, the allowance between the latter would have to be at least 140 feet unless there is sufficient margin beyond the goal-lines where the major part of the diamond can be accommodated.

Softball

This modification of baseball does not require such a large area, and the space requirements are shown in diagram Fig. 10.

Rounders

This old English game, which is probably the fore-runner of the two American games just previously mentioned, is popular with many schools, girls clubs, and youth organizations. The space requirements are as indicated on diagram Fig. 11.

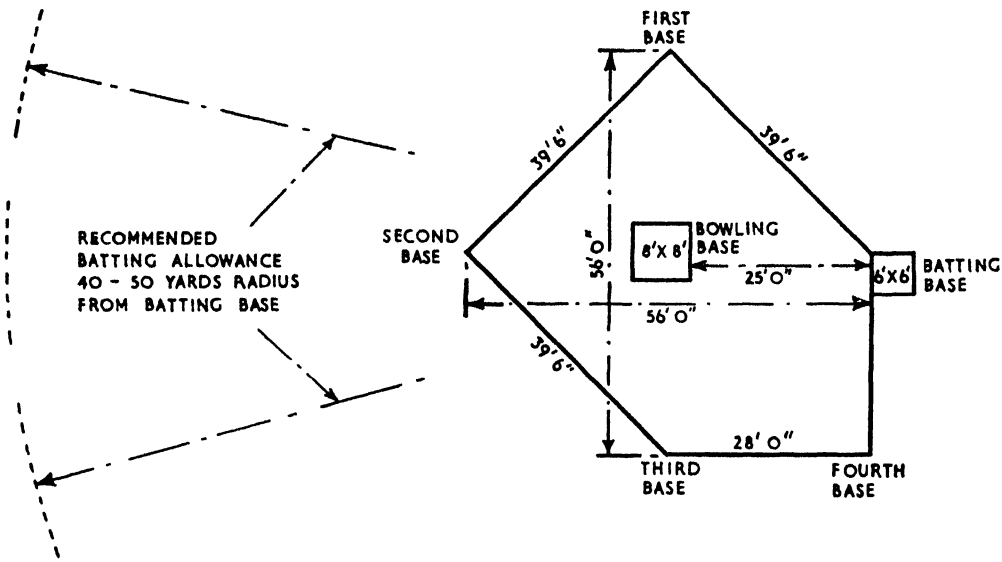


FIG. 11. ROUNDERS

Other Field Games

It is impossible to cover comprehensively in a work of this nature all the various field games fostered by educational institutions and other specialized organizations concerned with physical recreation for youths and adults. It would be both impracticable and uneconomic to attempt to make provision of separate pitches for each individual organized game that might be demanded from time to time on public playing fields. The land is not available for such generous arrangements and alternative uses have to be made of the main pitches provided for those games in most popular demand, during the periods when they are not required for their principal purpose.

A field planned for football, hockey, cricket, and possibly netball can be used alternatively for any of the undernoted games for which facilities may be demanded and whose space dimensions do not exceed those of the main pitches already planned. Their accommodation is only dependent on marking out the required pitch on the most suitable area available. Where there

is any danger of confusion of playing lines, limewashes of different colours may be used for the alternative markings on the same area.

The space requirements for some of these other field games may be stated briefly as follows:

Basket Ball. Mostly played indoors; pitch 80 to 90 feet long by 40 to 60

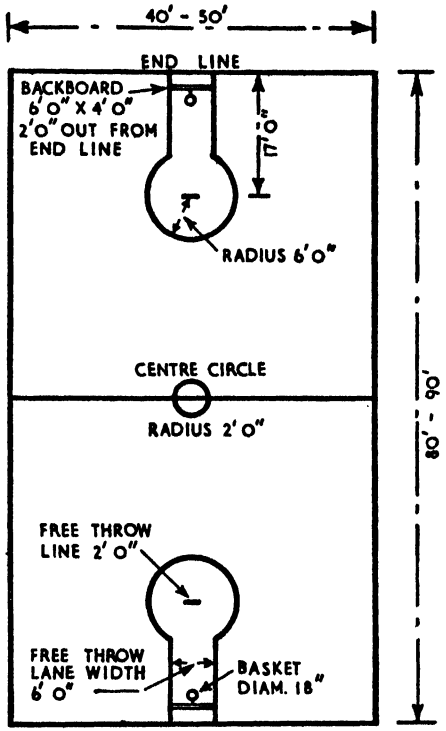


FIG. 12. BASKET BALL

feet wide. Where outdoor facilities are desired, these could be alternated with netball. For markings see Fig. 12.

Hazena. A women's ball game; pitch 45 to 50 yards long by 30 to 35 yards wide. Could be accommodated when required on either half of hockey field.

Field Handball. Any senior or junior football field will provide the space necessary.

Longball. Pitch 40 by 20 yards could be accommodated on either half of junior football or hockey pitch.

Stoolball. Wickets 16 yards apart can be accommodated alternatively to cricket along edges of cricket table with similar outfield allowances as for junior cricket.

Volley Ball. Court 60 feet long by 20 feet wide. Can be accommodated alternatively on any netball area.

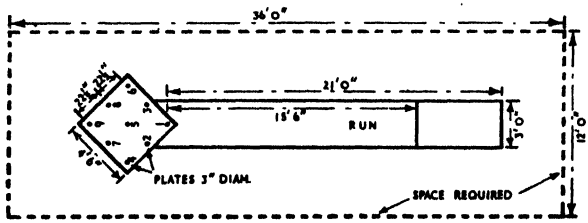


FIG. 13. SKITTLES

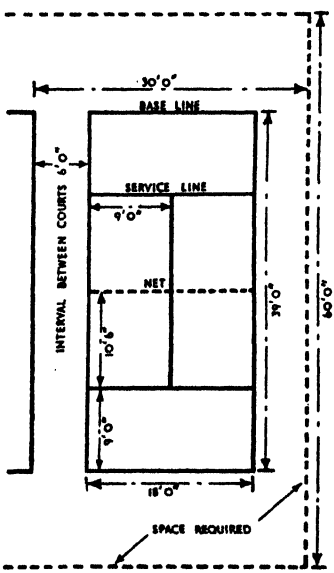


FIG. 14. PADDER TENNIS

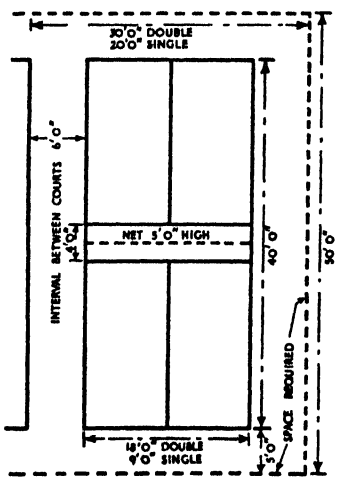


FIG. 15. QUOIT TENNIS

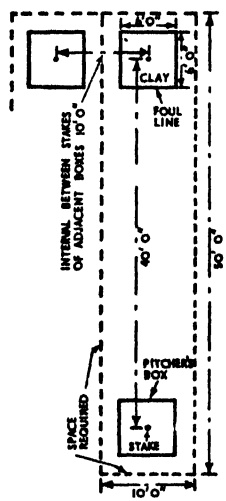


FIG. 16. HORSESHOE QUOITS

Court Games for Small Spaces

(1) *Skittles.* Space required 36 by 12 feet (see Fig. 13).

(2) *Padder Tennis.* Base-line to base-line 39 feet by 18 feet wide over side-lines. Overall dimensions per court 60 feet long by 30 feet wide. Where two or more courts in same enclosure, add a further 24 feet in width for each additional court (see Fig. 14).

(3) *Quoit Tennis.* Single court 40 by 9 feet. Double court 40 by 18 feet.

Over-all space allowance, say 50 by 20 feet for singles and 50 by 30 feet for doubles (see Fig. 15).

(4) *Horseshoe Quoits.* Requires a space 50 by 10 feet per court. The stakes are 40 feet apart set in the centre of clay ends 6 feet square (see Fig. 16).

(5) *Shuffleboard.* Court dimensions 52 feet long by 6 feet wide with 3-feet marginal surrounds or interval between adjacent courts (see Fig. 17).

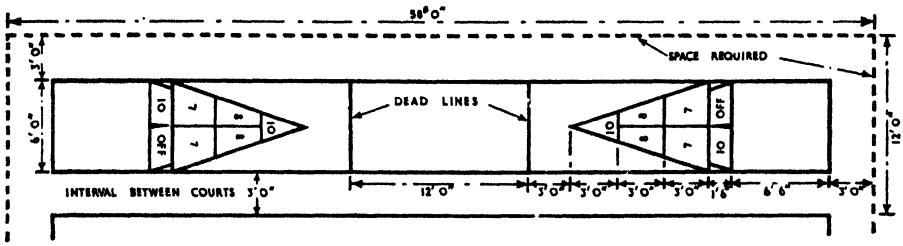


FIG. 17. SHUFFLEBOARD[1]

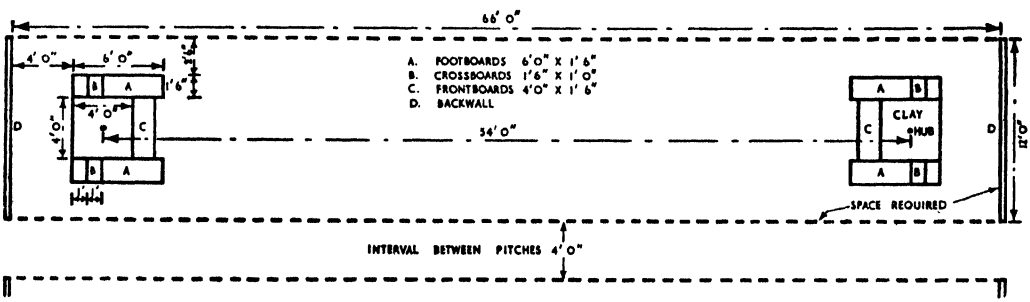


FIG. 18. QUOITS

(6) *Quoits.* Space required 70 by 12 feet. The hubs are 54 feet apart in the centre of clay beds 4 feet square (see Fig. 18).

(7) *Knock-up-walls.* Where space can be afforded a knock-up-wall 10 to 12 feet high of reinforced concrete or brickwork for practice at tennis or similar court games is often appreciated. The dimensions of court space would be as recommended for tennis for one-half of the court or courts.

Children's Playgrounds

It is not always easy to arrange space for children's playgrounds solely on a basis proportionate to the child population of the district. The area and quantity or type of equipment have to be frequently limited through financial considerations. Further factors determining the minimum space requirements are:

[1] The Shuffleboard marking shown in Fig. 17 is that adopted by The National Shuffleboard Association of America. There are other variants in use.

(*a*) The type of playground, whether fully or partially paved.
(*b*) Whether or not such features as paddling pools or sand-pits are to be included.
(*c*) The space, if any, required for organized games.

Where the playground forms part of a general playing field and facilities for children's organized games have been provided on the main grass area either as separate pitches or by the alternative use of adult pitches when not required by the seniors, then it may be sufficient to provide a suitably paved area to accommodate a number of mechanical attractions such as swings, slides, roundabouts, and the like. The space for these will depend, of course, on the number and type of amusements which can be afforded in any particular case, but a minimum allowance of 40 superficial feet per child of elementary school age with an aggregate area of not less than 3,600 superficial feet should be reasonable for the erection of a suitable selection of such equipment.

The area mentioned would have to be increased, of course, where it is desired to include a paddling pool, sand-pit, or an area for unorganized play such as roller skating, top spinning, and similar pastimes. The additional allowances per child for these features should not be less than the undernoted:

Paddling pool: 15 superficial feet per child, minimum aggregate 300 superficial feet.
Sand-pit: 7½ superficial feet per child, minimum aggregate 150 superficial feet.
Unorganized play space: 40 superficial feet per child, minimum aggregate 3,600 superficial feet.

The undernoted tables give the safety clearance dimensions recommended for various types of playground equipment in popular demand. They have been arranged in accordance with the recommendations of the National Playing Fields Association with due regard to their comparative safety in use on playgrounds with or without constant supervision.

It will be observed that the National Playing Fields Association limits the range of playground equipment for playgrounds where no regular supervision by a responsible attendant is practicable, to those items whose movements are regular and predictable, or where the design improves the facilities for old-established children's amusements with a consequent inherent appreciation of any risks involved. Where the movements are

PLAYGROUNDS WITHOUT SUPERVISION

TYPE OF EQUIPMENT	SAFETY CLEARANCE DIMENSIONS
SWINGS	
8′ high (cradle seats)	
Two seats (1 bay)	18′×21′
Three ,, (1 bay)	21′×21′
Four ,, (2 bays)	24′×21′
Six ,, (2 bays)	30′×21′
10′ high	
Two seats (1 bay)	18′×30′
Three ,, (1 bay)	21′×30′
Four ,, (2 bays)	27′×30′
Six ,, (2 bays)	33′×30′
MERRY-GO-ROUND	22′ diameter
WHIRLING PLATFORM	22′ ,,
SLIDE	
30′ long	48′×7′
40′ ,,	58′×7′
50′ ,,	70′×8′
ROCKING BOAT	21′×9′
ROCKING HORSE	18′×9′
SEE-SAW (non-bumper)	18′×4′

PLAYGROUNDS UNDER ADEQUATE SUPERVISION MAY INCLUDE THE FOLLOWING IN ADDITION TO THOSE IN PREVIOUS TABLE

TYPE OF EQUIPMENT	SAFETY CLEARANCE DIMENSIONS
JOY WHEEL	24′ diameter
OCEAN WAVE	24′ ,,
PLANK SWING	
Small size	30′×18′
Large size	42′×18′
PENDULUM SEE-SAW	
Small size	30′×18′
Large size	24′×15′
PLANE SWING (two-seater)	
Two swings (1 bay)	21′×30′
Four swings (2 bays)	33′×30′
Six swings (3 bays)	42′×30′
ROWING SEE-SAW SWING	30′×18′
SEE-SAW LADDERS	
Set of two ladders	15′×6′
Set of three ladders	15′×9′
JUNGLE GYM CLIMBING APPARATUS	
16′ 8″×8′ 4″×10′ 5″ to top	29′×21′
10′ 5″×10′ 5″×10′ 5″ to top	28′×23′
7′ 6″×5′ 8″×8′ 4″ to top	14′×12′

TYPE OF EQUIPMENT	SAFETY CLEARANCE DIMENSIONS
GIANT STRIDES	
Large, 17′ high	48′ diameter
Small, 12′ high	36′ „
TRAPEZE RINGS 20′ high	81′ × 15′
HORIZONTAL LADDER 6′ 6″ high	18′ × 6′
HORIZONTAL BARS	
Set of two, 4′ 6″ and 5′ 6″ high	18′ × 10′
Set of three, 4′, 5′ 6″, and 6′ high	25′ × 12′
PARALLEL BARS	10′ × 6′
GYMNASTIC FRAME	
With rings, climbing rope, horizontal bar, climbing bar, and trapeze	36′ × 21′

eccentric, and of varying sweep, the mechanism fairly large and of such a height that toddlers might wander inadvertently beneath the moving parts, or rough and boisterous manipulation may endanger other users, the Association considers that adequate supervision is very desirable to reduce risk of accident.

Gymnastic equipment properly used will provide undoubtedly healthful exercise, but the Association does not favour its use on outdoor playgrounds without safety mats and supervision by a trained gymnast. Otherwise there may be a considerable liability for accidents. Where gymnastic equipment, or climbing apparatus such as jungle gym is erected on playgrounds, the safety area should be formed to an adequate depth of not less than 15 inches of some soft and resilient material such as a mixture of granulated peat and sharp sand to cushion any accidental falls.

Paddling pools and sand-pits are popular attractions with children but should only be installed where frequent changing or sterilization of the water or sand is assured. Where these precautions are not practicable their condition rapidly becomes highly insanitary with consequent risk to the health of the children using them.

Playgrounds forming parts of playing field schemes where the total area will not allow allocations on the basic individual recommendations outlined above should be proportioned in accordance with the total acreage as follows:

Grounds of 6 acres or less, a minimum of 400 square yards for the erection of playground equipment and a further 400 square yards in extension of paved surface for unorganized play. Grounds exceeding 6 acres in extent should provide play areas on a *pro rata* basis.

No independent children's playground should be less than ¼ acre in extent if a reasonable area for equipment and space for unorganized play is required. Where an organized-games pitch is to be included in addition to the paved and equipped area, a minimum of 1 acre is very desirable.

Athletic Facilities

Increased facilities for athletic competitions and training are an urgent necessity in all parts of the country. We have undoubtedly among our youth some of the finest potential athletes in the world but unfortunately too many are unable to attain full development of their powers through lack of opportunities for training and the experience that can be gained only by competitive meetings. To remedy this deficiency, it is suggested that every residential area with a population of 30,000 to 40,000 should endeavour to provide on one of their playing fields a reasonably equipped arena where field and track events could be efficiently staged and systematic training encouraged.

The main difficulty, of course, has been that the formation of a cinder-track and its usual complements breaks up the continuity of the general turf area for organized team games and appreciably curtails the number of pitches that might otherwise be accommodated. Surely, however, it cannot be contended that the recreational needs of the community are being reasonably and fairly met by completely ignoring the claims of one section in order to provide more liberally for others. This has too long been the lamentable attitude adopted towards field and track athletics and it is time for a special effort to achieve a more equitable balance.

A further question is often raised as to whether there will be sufficient support to cover the cost of maintenance, although this aspect is seldom so fully explored in relation to many other recreational amenities. Can it be seriously upheld that financial returns are the sole criteria as to the value of physical recreation to the health and well-being of our people? It surely cannot be doubted that, though difficult to assess completely and accurately in terms of finance, the dividends returned by the improved physique and the mental and bodily fitness of our citizens are no less real and appreciable.

It is hoped that some of the diagrammatic arrangements shown may stimulate our local authorities to consider what is being or can be done to meet the needs of our young athletes, and may suggest ways of accommodating athletic facilities in some form or other on existing or projected playing fields where there is a large youthful population to be served.

Running Tracks

The most popular types of running tracks are those of four laps to 1 mile, but where these are inconvenient to fit into the general scheme, tracks of other lengths, within certain limits, are better than none at all. Whatever the circuit adopted, however, a straight for sprint events 420 feet long should be provided, either independently, or preferably, by extending one of the parallels of the circuit. This length would allow an assembly margin of 15 feet before the starting mark for sprint events and an over-run of 45 feet beyond the finish of the 120 yards hurdles. These arrangements are generally accepted as adequate.

It must be noted that the length of any track circuit is measured on a line 1 foot within the track from the inner edge. The proportions of any track, therefore, with curved ends of equal radii, can be determined from the formula:

$$L = 2D + 2\pi(R - 1),$$

where:

L = Length of track, in feet.
D = Length of parallels, or distance apart of centres of curves, in feet.
R = Radius to inside edge of track, in feet.

As all track events up to 440 yards are run in lanes, it is important that the track width should be sufficient for at least 4 lanes. Wherever space will permit, however, 6 lanes are preferable, but whatever the width of track that may be adopted for convenience on the circuit the straight for sprints should always be 6 lanes in width wherever possible.

Standard recommendations for lane widths are from 4 feet to 4 ft. 6 in. for each runner. Accordingly, over-all track widths for 4 lanes may be from 16 to 18 feet and for 6 lanes from 24 to 27 feet in relation to the most convenient lane width that can be arranged.

The diagram Fig. 19 and table below give some of the more popular dimensions for setting out tracks and their over-all space requirements. For good competitive meetings, tracks with curves of less than 90 feet radius are not recommended.

Where it is not expedient to lay down a cinder track, courses for running, of any suitable length may be readily marked out where required on the main turf area of the playing field. Some suggestions on these lines are shown by one or two of the diagrams included later in the section on planning. The main objection to these arrangements, however, is that the use of the

ground for running will have to be restricted to those periods when the area traversed by the track is not required for other games and, furthermore, that space for the jumping pits and other field events has to be found on odd

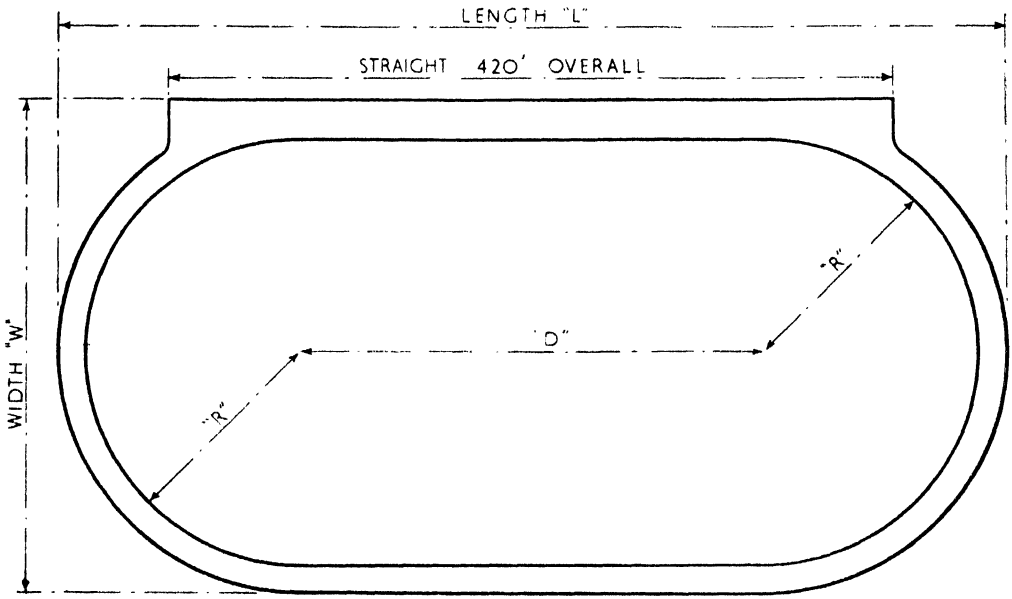


FIG. 19. ATHLETIC TRACK DIMENSIONS

LENGTH OF TRACK	LAPS TO 1 MILE	LENGTH OF PARALLELS 'D'	RADIUS TO INSIDE EDGE OF CURVES 'R'	OVER-ALL LENGTH 'L'		OVER-ALL WIDTH 'W'	
				4 LANES	6 LANES	4 LANES	6 LANES
yards		*ft.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*
330	5⅓	135	113 7	398 2	416 2	263 2	281 2
352	5	150	119 4	424 8	442 8	274 8	292 8
352	5	180	109 9¼	435 6½	453 6½	255 6½	273 6½
352	5	210	100 2⅝	446 5¼	464 5¼	236 5¼	254 5¼
440	4	225	137 5½	535 11	553 11	310 11	328 11
440	4	240	132 8¼	541 4½	559 4½	301 4½	319 4½
*440	4	270	123 1⅝	552 3¼	570 3¼	282 3¼	300 3¼
440	4	300	113 7	563 2	581 2	263 2	281 2
440	4	330	104 0½	474 1	592 1	244 1	262 1
440	4	360	94 6	585 0	603 0	225 0	243 0

Note: The over-all dimensions given to gauge space requirements are based on a maximum lane width per runner of 4 ft. 6 in.

The dimensions marked* are those considered by athletic authorities as giving the ideal track circuit.

For serious competitive events tracks other than four laps to the mile are not recommended.

areas along the margins of the outfield. This dispersal of athletic facilities complicates the organization and management of meetings for competition and training, and the whole general arrangement will only permit intermittent use of the ground for the purposes intended. Consequently, provisions of this character should only be contemplated where there is no

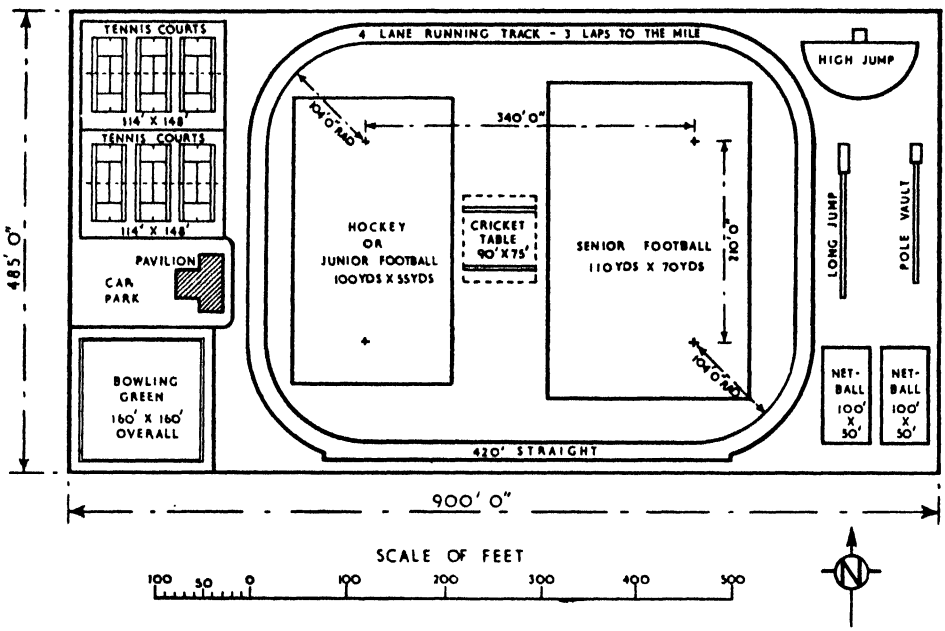


FIG. 20. INDICATING ARRANGEMENT OF RUNNING TRACK ON THE PERIMETER OF MAIN TURF AREA. *Approx. 10 acres*

better alternative or as a temporary measure pending the establishment of a more adequate permanent sports arena.

On larger grounds it may be possible to allow sufficient margin round the boundaries of the organized games area where a running course of suitable length could be permanently set out on the turf, or a proper cinder track constructed. Fig. 20 shows a typical arrangement on these lines.

Where the circuit is on grass, and sufficient space is available on one side, it is a great advantage to provide an independent cinder straight of sufficient width for the sprint events.

In arranging tracks of this type with four straight sides and four curved corners of equal radii, it is useful to remember that, if the curve radius is 104 feet to inside edge, the length of the track round the bends will total 220 yards. Consequently the length of the straights which in conjunction

with these curves will give a track of any desired length, can be readily determined.

Fig. 21 shows the general arrangement of an athletic arena including a cycling track. The running track of 4 laps to 1 mile is of the ideal dimensions, while the cycle track is of $3\frac{1}{2}$ laps to 1 mile. It will be noted that these arrangements will only permit of 4 lanes of maximum widths on the circuit of the running track, but the straight can be increased to 6-lane width on one side. Where no cycle track is required and circumstances will permit, the circuit should be preferably 6 lanes in width.

The arrangements shown have been fully approved by the Amateur Athletic Association and it will be evident that a track of these dimensions will allow room on the central turf area for a senior football pitch of average first league dimensions with space in the margins and ends for siting the jumping pits with their necessary run-ups and also for bases required by other field events.

A cycle track requires an appreciable super-elevation on the curves, depending on the radius and the type of surfacing used. Quite apart from any limited allowance that may be made on the surrounds for spectators, therefore, a sufficient margin will be essential for trimming the external banks of the super-elevation to a suitably stable batter.

The ground space requirements for such an arena with cycle track would be approximately 660 feet long by 390 feet wide or approximately 6 acres. Without the cycle track, but with the running track of six lanes in width (27 feet), the ground space requirements would be approximately 590 feet long by 320 feet wide or approximately $4\frac{1}{3}$ acres.

Cycle tracks of four laps to the mile with running tracks of four and a half laps to the mile inside reduce the centre area to such an extent that it is difficult to provide a good straight for sprints without seriously cramping the remaining space for field events, and senior football on the centre becomes impracticable. Such arrangements therefore, cannot be recommended as satisfactory for permanent sports arenas.

The super-elevation shown for the cycle track are those recommended by the National Cyclists Union and are applicable where it is proposed to hold meetings of the international type. They would probably be too costly to construct for the general run of public playing fields where the aim is to get people actively engaged in various sports, and not as a spectacle. There is no doubt, however, that where space can be spared to provide sufficient terracing for spectators, cycle racing can be made a great attraction for the

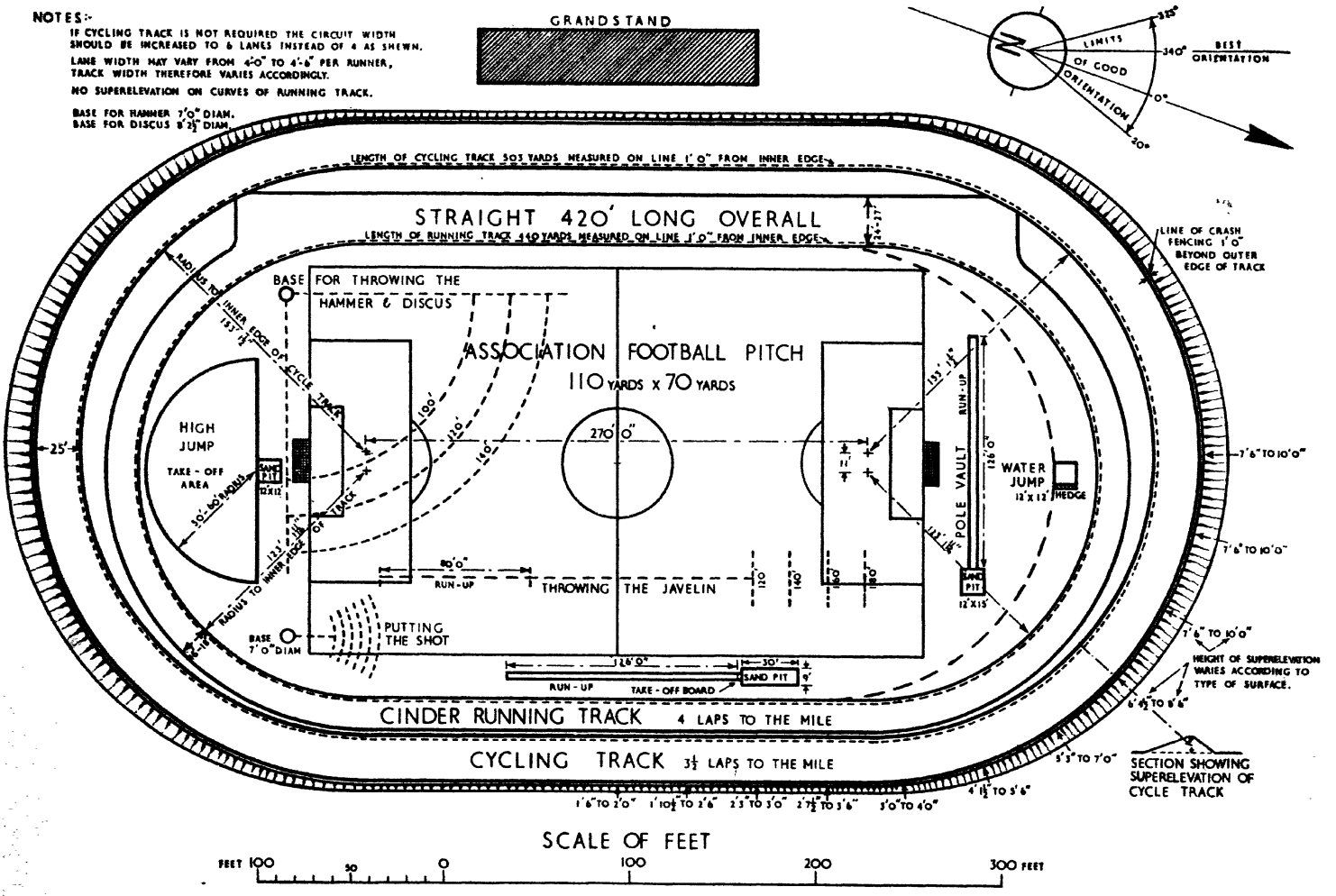


FIG. 21. ATHLETIC ARENA

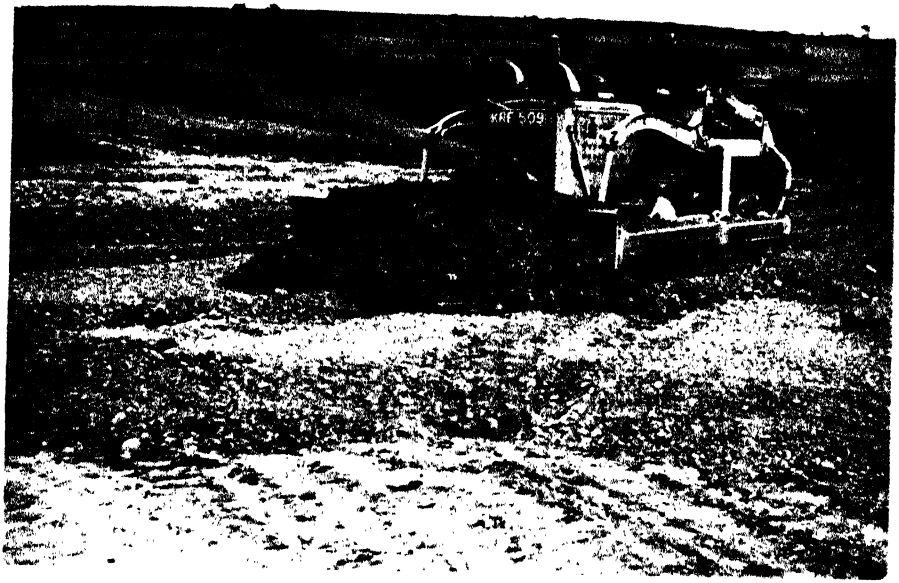


PLATE 4. *Another type of Bull-dozer at work. The advantages of working the soil when dry can be appreciated from this photograph*

PLATE 5. *Excavating by heavy Crawler Tractor and Scraper*

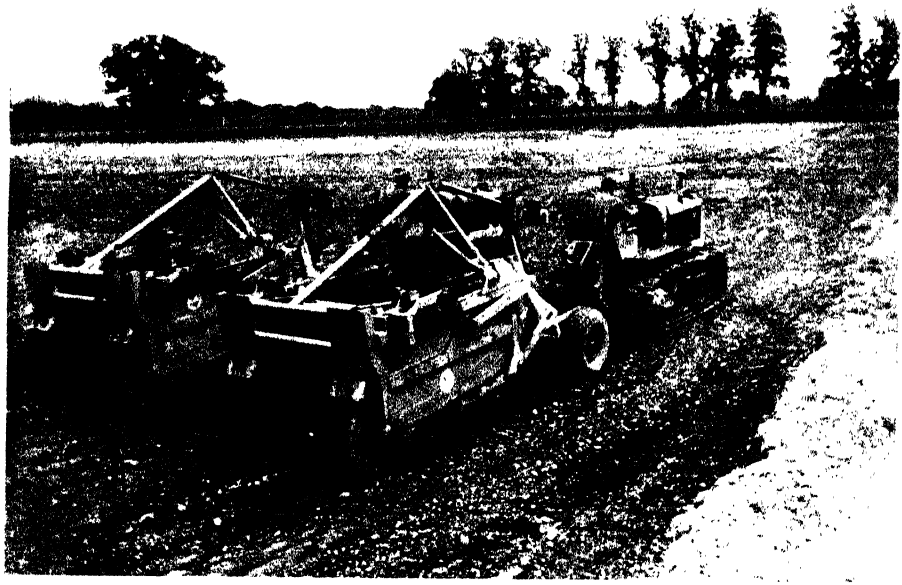


PLATE 6. *Crawler Tractors and Scrapers transporting soil*

PLATE 7. *Surfacing with Scraper nearing completion*

general public, and the gate receipts for regular meetings would greatly contribute to the cost of maintenance of the ground. For normal circumstances however, banking on the curves one-third to one-half the amounts shown would be adequate for the average enthusiast.

Training centres for athletic practice and coaching, where space is not available for an arena of dimensions suitable for competitive meetings, can do much to stimulate interest in both field and track events. Many suggestions have been put forward for the encouragement of such training with fantastic claims regarding the limited space requirements entailed. In the main, such suggestions centre round providing a large jumping pit, sufficient for long jump, pole vault, and high jump, but the fact is frequently overlooked that while such a pit can be sited in a convenient odd corner or marginal space on the out field, the take-off allowances must frequently overlap other playing pitches, especially where the field has been developed to its maximum playing capacity, and therefore the use of the ground for athletic training will have to be confined to those periods when the adjacent section of the ground is not in use for other games. Such intermittent use cannot be considered satisfactory to athletes, players, or ground staff, and if practice for other field events such as the javelin, hammer, discus, and putting-the-weight is to be allowed, still further restrictions will be imposed on users of the various facilities provided.

It is much better to arrange training facilities on an independent area of sufficient dimensions to afford ample opportunities for simultaneous training and coaching in all branches of athletics. The diagram in Fig. 22 shows such a layout which can be comfortably accommodated on a 3-acre site. The track circuit of ten laps to 1 mile is much too sharp on the curves for serious competitive work, but provides a suitable course for limbering up exercises, stamina tests, and for the development of good track technique. The full-length straight for sprints is very desirable where space will allow, as the maintenance of maximum effort throughout the whole course is essential to success over short distances, and training, therefore, over partial lengths can never be wholly effective.

It will be noticed that adequate area remains for the practice of other field events either within or around the track circuit as indicated, and the only section where training would be alternated would be that devoted to the hammer and discus.

A suitable small pavilion with changing-rooms, showers, and conveniences would be essential, and the all-round advantages of complete training

facilities of this nature over the makeshift odd corner or marginal arrangements which can seldom be made to function satisfactorily in practice, should be obvious.

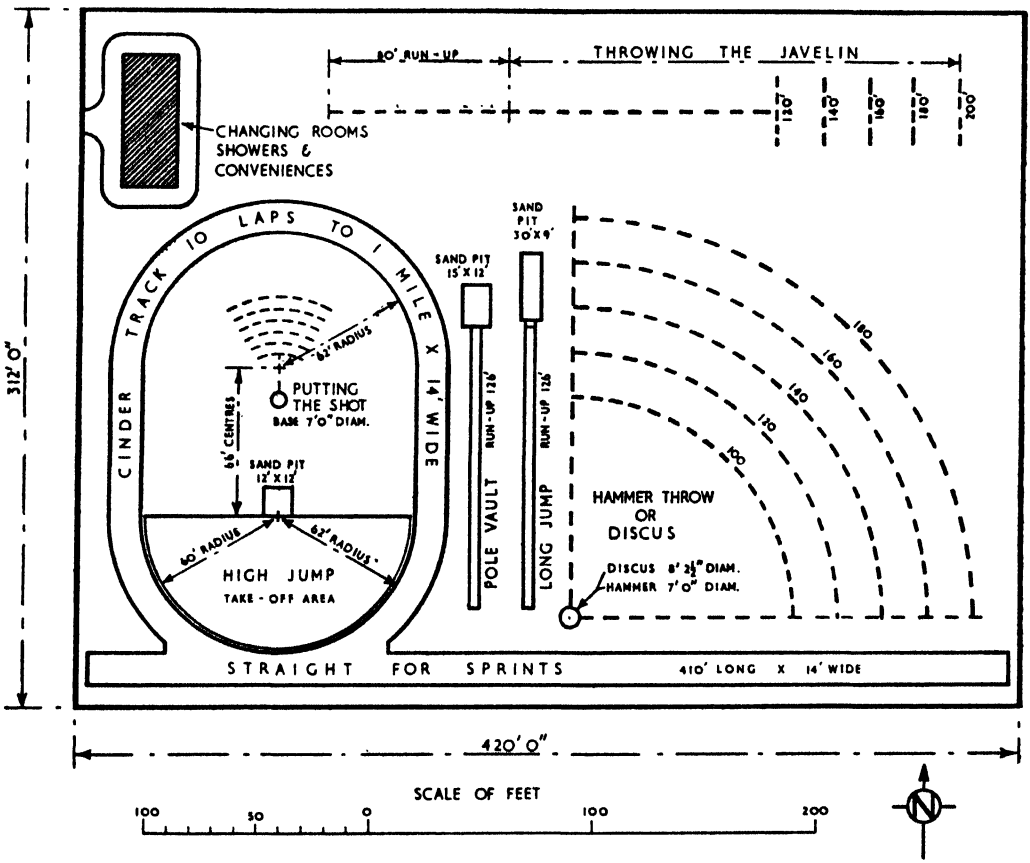


FIG. 22. A TRAINING AREA FOR ATHLETICS
Approx. 3 acres

Pavilions &c. The space to be reserved for pavilions, shelters, and changing-rooms will have to be decided in accordance with local habits and aspirations. For small village fields with few games facilities, a simple building of two rooms providing changing accommodation for home and visiting players with the usual conveniences may be adequate. Larger fields with a wider range of facilities would require a much more elaborate pavilion with a separate dressing-room for each home and visiting team of both sexes and appropriate sanitary and cleansing amenities. In addition, there may be a demand for central lounge, club-room or cafe, small kitchen, drying-rooms,

office, store-room, and verandah. Living accommodation for a steward or groundsman may be required to be included in the building in certain cases.

It would be inadvisable, therefore, to attempt to lay down any hard and fast rules as to space requirements for these buildings. The design should always be entrusted to a competent architect who will be able to advise the most suitable type of building to comply both economically and effectively with the needs of the community.

There are, however, certain minimum basic standards which the Association desires to see upheld in connexion with the planning of these buildings, especially in relation to the dressing-room and sanitary arrangements.

Dressing-rooms. These should be proportioned to provide a floor space of not less than 9 superficial feet per person for adults and $7\frac{1}{2}$ superficial feet per person for schools.

For private clubs where separate numbered lockers are required in dressing-rooms, the floor space would have to be appropriately increased. This locker provision however, is much too extravagant for average public playing fields where it is usual merely to instal sufficient seating accommodation round the walls with space below for boots or bags, and a hanging peg above for each player. Seating should be on the basis of 2 feet run per person with a minimum width of 1 ft. 4 in.

Conveniences. The sanitary arrangements practicable will be largely dictated by local circumstances. If there are adequate public services of water-supply and main drainage, and the finances available will permit, provision may be made on a fairly generous scale. Where, however, such services are severely restricted or non-existent, as in many rural districts, the sanitary arrangements will consequently have to be curtailed accordingly.

Wherever possible the Association recommends conveniences not less than the following:

Males: 1 W.C., 1 urinal stall, 1 wash-hand basin, and 1 shower for every 25 persons.

Females: 2 W.C.s, 1 wash-hand basin, and 1 shower for every 25 persons.

It follows, of course, that where there are no public water-supply or water-borne sewerage systems, these arrangements will not be practicable, and earth or chemical closets will have to be substituted on a scale consistent with the facilities for emptying and sterilizing. Washing facilities will also have to be scaled down in accordance with the method of supply and adequacy of the water available.

The recommendations are offered as an absolute minimum with a view to avoiding undue extravagance, or the setting up of standards impossible of attainment in the majority of cases. It is realized that efficient sanitary installations involve an appreciable capital expenditure quite apart from the costs of running and maintenance. For this reason, the inclusion of plunge baths in addition to showers has not been mentioned although they are highly favoured, especially by rugby footballers, where they can be conveniently installed. Plunge baths do, however, require a much more generous water-supply and boiler capacity than can be generally afforded on normal playing field schemes.

All supply valves for basins and showers should be wherever practicable of the self-closing type to ensure the minimum use of water, and to prevent unnecessary waste.

In determining the number of fittings in relation to users it has been assumed that where a number of pitches are being used for games served by the one pavilion, times of play may be slightly staggered so as to avoid all games concluding at the same time with a consequent over-taxing of the available arrangements for ablutions.

Dimensions of conveniences should not be less than the following:

W.C. compartments: 4 ft. 6 in. by 2 ft. 6 in. each.
Urinal stalls: 2 feet run per person by 1 foot to 1 ft. 6 in. according to type.
Showers: 3 by 3 feet each.
Wash-hand basins: 2 feet run per person by 1 ft. 6 in.
Circulation space should be at least 3 ft. 6 in. between any group of conveniences.

The general arrangements of the remaining sections of the building will have to be decided in accordance with their functions. Where a central lounge or club-room is considered desirable for meetings of clubs using the field this would have to be of adequate dimensions to the numbers expected to attend. Kitchen requirements will generally be restricted to facilities for making tea or other beverages, and the preparation and dispensing of sandwiches and similar light meals, which do not demand cooking utensils.

The boiler room for hot-water supply or heating will depend on the washing facilities included, and the method of heating most convenient. Where fuel has to be stored, adequate space should be allowed for the season's supplies.

In some private clubs, the club-room of the pavilion is sometimes desired for use for indoor games such as badminton or for dances, or alternative use as a gymnasium. In such cases, the dimensions will be determined from the recreational requirements rather than purely assembly space. For example, if used alternatively as a gymnasium or for a badminton court, the dimensions should not be less than 56 by 30 feet with a clear height of not less than 15 feet.

Drying rooms if provided should be separate for each sex of players. They should be fitted with convenient racks and well heated and ventilated.

Entrances to dressing-rooms should be direct from the field of play and not through the club-room or lounge.

Tennis and bowls players seldom require changing-rooms. Normally they come dressed for the game and only require facilities for changing shoes and hanging their outer garments. Consequently on larger fields it is usual to provide a small single-roomed pavilion with sliding doors, or an open-fronted shelter for their use with the usual conveniences at the back. In the case of bowls, where woods and rubber slips or shoes are to be hired out, if these are not controlled from the main pavilion then a hut for their storage and issue would be necessary at the side of the green.

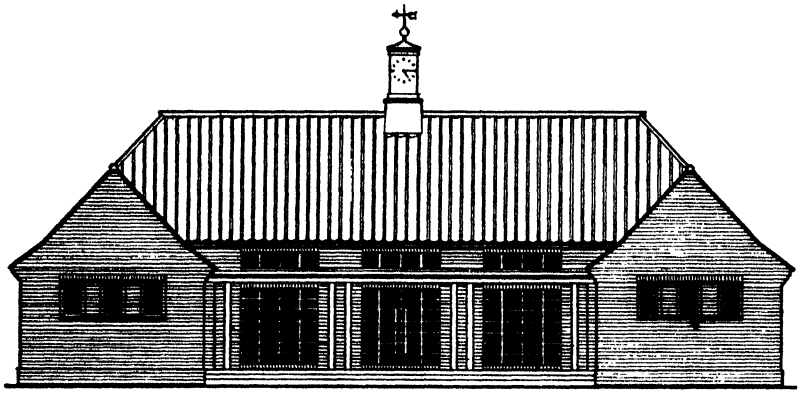
An open-fronted shelter of suitable dimensions with conveniences for both sexes should always be a feature of every children's playground.

Fig. 23 shows a design for a pavilion for a small playing field (6 to 8 acres) or sports club. The minimum accommodation comprises a common changing-room for members and visitors of each sex, together with the necessary conveniences including wash-basins and showers.

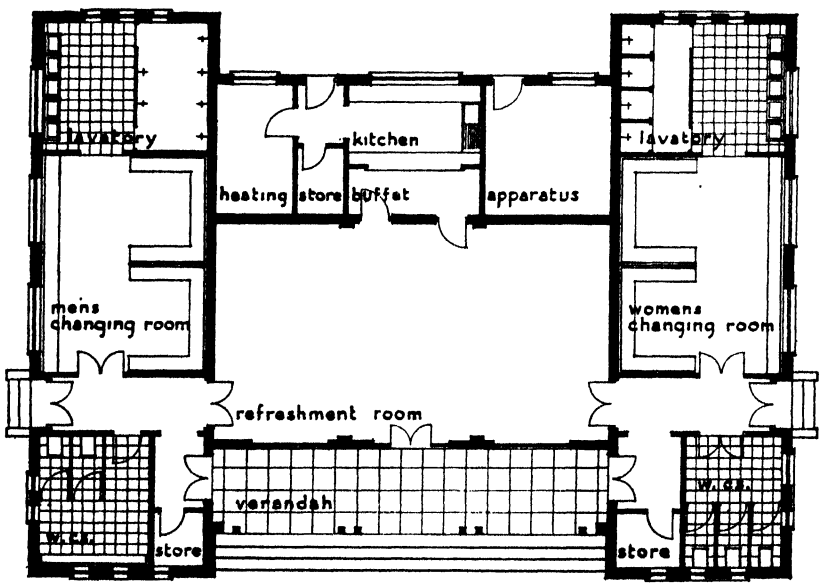
A large central refreshment or club-room is provided with direct access to the dressing-rooms and conveniences. Separate entrances to dressing-rooms and conveniences direct from the field are also a feature of the design to avoid entry to the central room by players in muddy boots. A small heating chamber, kitchen with buffet bar, and store-rooms for games equipment and other requisites are also provided, and there is an attractive paved verandah in front from which games may be viewed.

Fig. 24 shows a design for a pavilion suitable for larger sports fields, providing separate changing-rooms for members and visitors of each sex with necessary conveniences, wash-basins, and showers. It will be noticed that the plan could be quite easily extended to provide additional dressing-rooms that may be required by any particular scheme.

Similar general features as regards entrances, club-room accommodation,



FRONT ELEVATION



PLAN

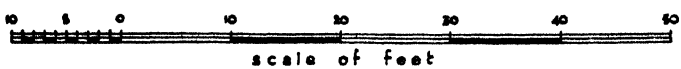
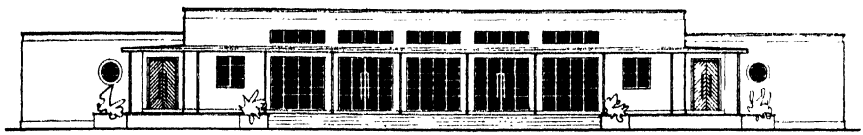


FIG. 23. DESIGN FOR A SPORTS PAVILION

heating chamber, kitchen, and stores have been included as in the previous case and the office, if not required, could be used as a changing-room for referees and other games officials.



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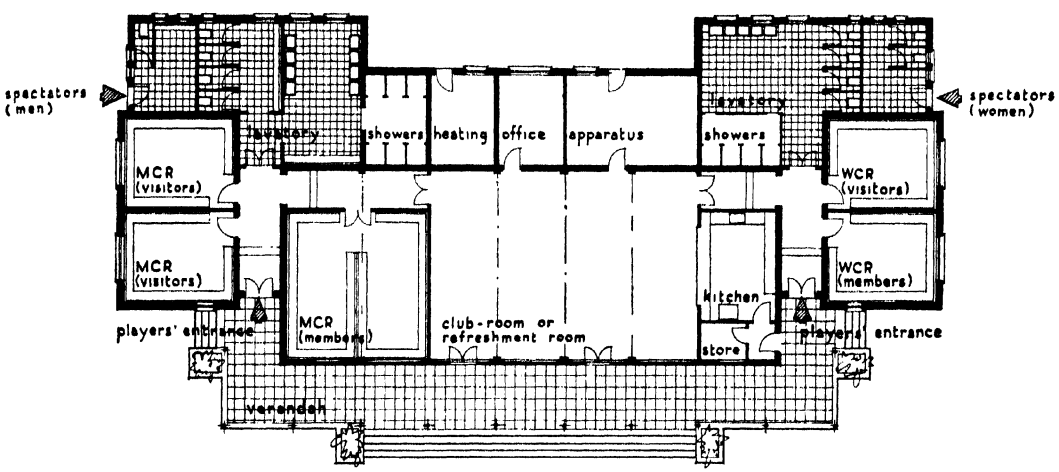


PLAN

MCR - mens changing room WCR - womens changing room

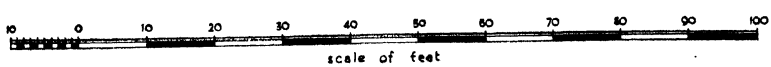


FIG. 24. DESIGN FOR A SPORTS PAVILION

The type of construction, finish, and equipment in either case will naturally depend on local conditions and available finances. Space and water-heating arrangements will be governed by the services available. Where there are local gas and electric services and the use of the building is confined to odd days and week-ends, either of these two types of services

or a combination of both will be found most convenient and economical in the long run. Where, however, a site cannot be supplied with either of these two services recourse will have to be made to a suitable boiler and solid fuel.

The author is indebted to Messrs. H. A. Rowbotham and T. L. Smithson, A/L.R.I.B.A., for the preparation of these designs.

Car parks. The Association fully appreciates the importance of providing a reasonable space for the parking of cars and other vehicles transporting players to the field. It is extremely difficult, however, to determine what is a reasonable allowance in every case. Obviously the demand will vary considerably with the location of the field in relation to the population it is to serve, available transport facilities, and the existence of any adjacent parking sites. At the same time a tendency has been noticed, when examining schemes submitted for approval, to sacrifice too great a space acquired for playing field purposes for the construction of elaborate car parks which the Association suspects would be used more by general motorists than by actual users of the ground.

The problem of adequate car parking space for the community as a whole is one that should be given serious consideration by all local authorities, and the Association cannot look with favour on land acquired for physical recreation being extensively reduced on the excuse that the space is necessary for car parking.

Accordingly, it recommends that parking space allowance within the boundaries of a playing field should not exceed 800 superficial yards per 6 acres. Where this proves inadequate, external arrangements should be contrived in the vicinity to meet the excess demands. There are few districts which can boast of the moderate standard of playing space advocated by the Association and it is essential therefore that the maximum development for playing purposes should not be prejudiced by the inclusion of ancillary features such as car parks to an excessive degree.

Golf facilities. The only golf facilities likely to prove practicable for inclusion on playing field schemes are putting greens, and approach or pitch and putt courses. The latter, when well laid out and maintained, generally prove extremely popular. They provide a form of recreation which is suitable to people of both sexes and all ages, and are therefore worthy of serious consideration where space is available.

The space requirements will, of course, vary with the type of layout, the shape of the ground, and the contours. For putting greens, the length of

individual putts should vary from 5 to 15 yards, with a clear space of $7\frac{1}{2}$ to 10 feet in any direction from the hole. A nine-hole putting green where the whole space is available for putting, would require an area of approximately 800 to 1,000 superficial yards with a minimum width of 15 yards. Eighteen holes would require a *pro rata* increase in space.

In some cases interest is added to the green by planting clumps of suitable shrubs between the various holes, and in such circumstances the area would of course have to be proportionately increased. It must be appreciated, however, that such planting rather restricts the opportunities for varying the direction of the shots from time to time, should the turf show signs of excessive wear through severe traffic. Miniature bunkers or hazards have no legitimate place on a putting green.

The area allowance for an approach course should be from $4\frac{1}{2}$ to 5 acres for a nine-hole course, or 9 to 10 acres for eighteen holes. Length of approach shots should vary between 35 to 90 yards if the green is to be reached by the average player in one shot from the tee with a mashie niblick, although longer holes may be included where other iron clubs are used. As a general rule, however, only two clubs are hired to players, a mashie niblick and a putter, and it is desirable therefore to keep the length of approach well within the capacity of the clubs supplied. The minimum width at any part of the course should not be less than 70 yards, to allow space for adjacent shots to pass with ample clearance. The size of greens on approach courses should be from 350 to 500 superficial yards in area according to the character of the approach, and should have a clear putting space of not less than 10 yards in any direction around the hole.

These golfing features are an excellent way of developing undulating areas which for economic or other reasons cannot be readily adapted to other forms of sport. They do, however, demand a very high standard of greenkeeping if they are to be maintained in a satisfactory playing condition. On the other hand, where there is sufficient population to justify their inclusion on any playing field, the revenue returns are usually more than sufficient to meet the costs of maintenance.

Swimming pools. While the National Playing Fields Association do not undertake the design of swimming pools, it is frequently requested to reserve space for facilities of this nature when preparing layout plans for some of the larger schemes. A very excellent brochure entitled 'Modern Public Baths' by Kenneth M. B. Cross, M.A., F.R.I.B.A., has been issued by The Amateur Swimming Association giving their recommendations on the design

and equipment of swimming baths both for indoor and outdoor use, and this publication should be studied by all who contemplate the provision of facilities of this nature.

It may be of interest to note, however, that the Amateur Swimming Association recommends a minimum size of 100 feet long by 40 feet wide for public swimming baths but prefer where circumstances will permit, dimensions of from 120 feet to 132 feet long by 48 feet wide, the measurements in all cases being from wall to wall. Where it is proposed to stage championship contests and acquatic sports measurements of 165 feet long and 60 feet wide are desirable.

The depth of water will normally vary from 3 feet or 3 ft. 6 in. at the shallow end to 8 feet at the deep end, but greater depths are necessary where high diving is to be encouraged, depending on the height of the diving stage.

The design and construction of swimming pools should always be entrusted to an experienced and competent specialist as the engineering problems to be solved are varied and complex and failure in any aspect may be extremely costly.

Reinforced concrete construction is the most highly favoured for modern swimming pools and the design must take into account the water-pressure; the distribution of the weight of the structure in relation to the bearing capacity of the soil; water-proofing; water-supply, filtration, and sterilization; main drainage; and the provision of the customary surrounds, equipment, conveniences, and other amenities as may be required by local circumstances. The over-all space requirements will be determined by the arrangement of the surrounds. There should be a paved margin around the pool of not less than 6 feet and many open-air pools require ample space for sunbathing beaches and lawns in addition to any provision that may be made for spectators.

III

PLANNING THE PLAYING FIELD

THE perfect layout of a playing field is seldom attainable. Apart from financial restrictions, which can never be ignored, the scope of the design may be frequently dictated by site peculiarities, such as irregular boundaries, severe surface contours, geological strata, the existing or proposed development on adjoining lands, and other local characteristics. The aim of the designer will be to seek the best compromise which will utilize the space available to the maximum in providing the type of games facilities and amenities desired, and the final ground arrangements should ensure reasonable comfort, safety, and convenience to users while at the same time effecting the greatest possible economy in construction and maintenance.

The desires of the community having been ascertained in relation to present and future recreational needs, the dimensional standards for the various games to be included in the scheme can be decided readily by reference to the recommendations given in the previous section on 'Space Requirements'. It should be a comparatively simple matter then to determine to what extent the desired facilities can be provided on the field without overcrowding or extravagance in the use of the space available. This can be efficiently accomplished by appropriately grouping together those facilities which are in some degree complementary to each other as regards certain aspects of management and maintenance or whose space requirements and basic constructional principles are more or less closely related.

The advantage of having a plan of the final scheme prepared at the outset, even where only partial development is contemplated immediately, is that it permits those features which have to be deferred for later inclusion to be so sited that, when their construction can be undertaken, the minimum interference will be caused to those sections of the ground which are already well established and in use.

Too many grounds have been brought into use as playing fields in the past without any attempt to gauge their ultimate possibilities in relation to future demands. They are started in many instances with some limited provision for field games like cricket, football, or hockey, and these are set

out often with thoughtless extravagance on what appears at the time to be most suitable positions. Later, when a demand is made for facilities for tennis, bowls, or a children's playground, it is found that, although there may be ample space available, this further provision will involve a radical rearrangement of the entire field, and the disturbance of existing established facilities to such an extent as may probably cause the suspension of play for a season or two. Consequently the revised scheme becomes unnecessarily costly, and there is in addition the annoyance to those whose recreational activities have been temporarily curtailed with a consequent appreciable loss of annual revenue. With ever-rising costs of labour and materials such irresponsible methods of playing field development should no longer be tolerated.

Location, and grouping of games facilities. The analytical diagram, Fig. 25, shows the most popular games sections included to a greater or lesser degree on public playing fields in the British Isles and their relationship in the general scheme. The main turf section of the ground is generally devoted to field games such as cricket, football, rugby, hockey, lacrosse, children's organized games, and similar activities. Where space is available areas may also be set aside for practice or as turf reserves. This grouping on one unbroken stretch of turf greatly simplifies maintenance as it allows mechanization of the usual routine operations to be practised to a major extent with marked economy and efficiency. Apart from occasional renovation or remedial work, hand labour can be practically restricted to wicket preparation on the cricket tables. A further advantage of effective grouping is the considerable saving of marginal space and surrounds that can be attained.

Athletic facilities, where required, can be included either by allowing sufficient space to be used at certain periods on the field-games section, or by means of a separate enclosure with a properly constructed cinder track of suitable dimensions. Various arrangements in this respect have been noted in the previous section and their advantages and disadvantages fully discussed. It should be a simple matter therefore to determine to what extent athletic facilities may or may not be arranged on any particular site. Where the area will permit, of course, a separately enclosed arena is the most satisfactory, but in such cases easy access from the main field section should always be arranged for the convenience of the ground staff.

In siting the main pavilion, several important factors must be considered. It should be reasonably adjacent to all the games sections it is to serve, if further expenditure on subsidiary pavilions or changing-rooms is to be

avoided. It should, as far as possible, overlook the entire field-games section of the ground with a clear uninterrupted view of both ends of the principal cricket table, and with an aspect wherever practicable avoiding

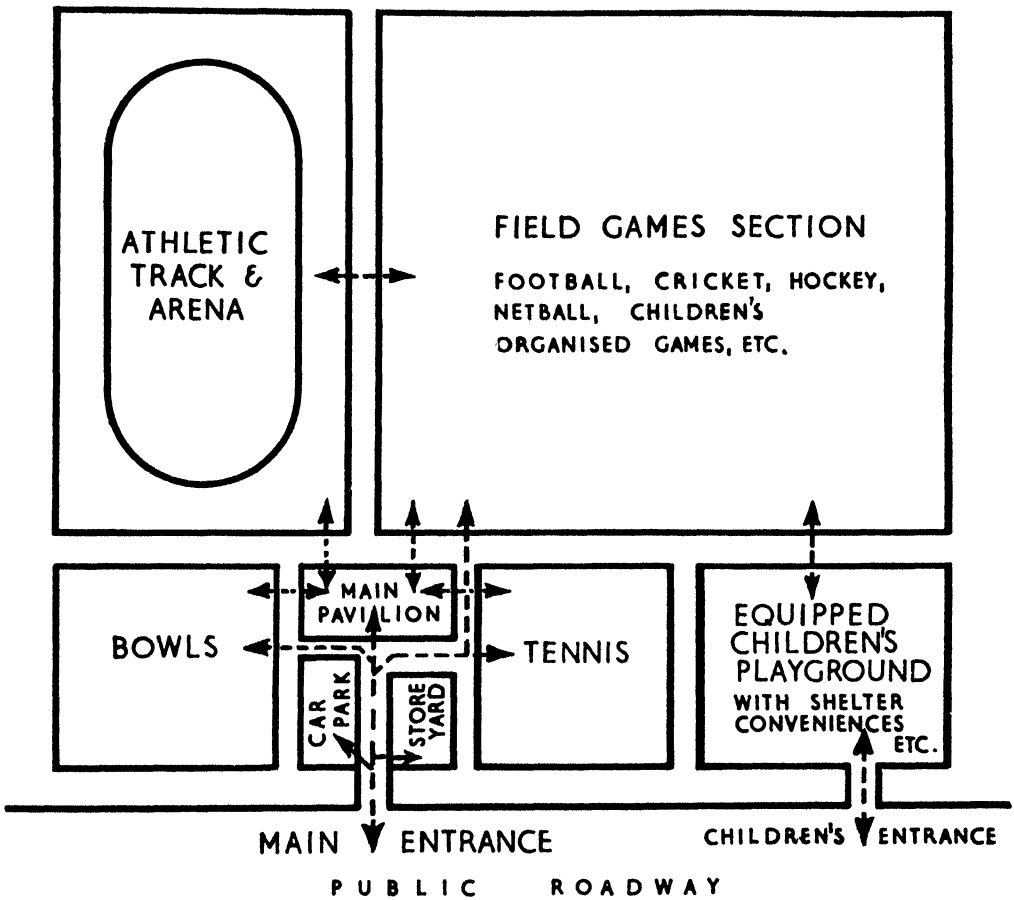


FIG. 25. ANALYTICAL DIAGRAM SHOWING THE MOST POPULAR COMPONENTS OF A PLAYING FIELD LAYOUT

the arc of geographical bearings between north-west to south-west. The location will also have to be considered in relation to the expenditure involved on access roads and connexions to public services, surface contours in relation to drainage and sewerage outfalls, and the minimum encroachment on playing space by the building and its approaches.

Obviously, for smaller fields with a single entrance from a public roadway with the usual service mains, the nearer the pavilion is to the road the

less will be the expenditure on approach roads and services. It will be obvious also, that the farther any building and its environs are projected into the field, the greater will be the loss of space for playing purposes, and the implications in this respect should be thoroughly investigated where the area for development is severely limited. To resolve all the locational factors satisfactorily is by no means easy, especially on fields of extensive acreage with several public approaches and points of access of equal importance to their respective sections of the community. In cases of this kind purely economic considerations should not be allowed to prejudice the solution which will ultimately offer the most equitable arrangement to management and user alike.

Bowling greens and tennis courts are usually grouped together in convenient blocks. Their space requirements can often be reasonably balanced, and there are many similarities in connexion with constructional and maintenance operations which can be more economically exploited by adjacent grouping. In order to avoid waste of space and expenditure on access paths or separate pavilion accommodation, they should be sited as near as possible to the main pavilion.

Other amenities which are essential to a well-planned field are a car park and a service yard and shed for the use of the ground staff. The car park is best situated near to the pavilion if this has been placed conveniently to all the games sections. The service yard may be sited in any suitably unobtrusive position which will allow it to be effectively screened off from the remainder of the ground. This yard must be of sufficient area to allow easy manœuvring of the various machines and implements in and out of the sheds while leaving space for the storage of soil, sand, grass cuttings, and for the preparation and weathering of compost heaps. Good access for heavy transport lorries bringing in supplies and equipment is essential to reduce manhandling in this respect. The sheds should be of ample dimensions to permit all machines, tools, and equipment to be housed under cover, and there should be a section fitted as a workshop where everyday minor repairs and adjustments can be accomplished speedily and efficiently.

Children's equipped playgrounds should be within easy reach of all sections of the community if they are to be attractive to children paying frequent visits of short duration. On smaller fields with single entrance, the nearer they are situated to the roadway the more convenient for the children and the less will be the restrictions on planning the other sections of the

field. Of course, there are other factors to be considered in the siting of these playgrounds. Good drainage conditions are essential and proximity to houses should be avoided wherever practicable.

Many people hold the view that for safety purposes children should be kept as far away from the roadway as possible—but surely the dangers from traffic only arise during entering or leaving the ground, and this risk has to be faced wherever the playground may be placed within the field. Steps should be taken to check the impetuous from rushing unheedingly into the traffic way by suitably arranged self-closing gates or barriers as will be described later. Also development plans should aim at providing pedestrian ways that will allow access to playgrounds clear of traffic roads.

On some larger fields with several entrances, it may not be possible to centralize the playground, and it may be advisable to provide the playground equipment on two or more sites as may be most suitable to the various sections of population using the field. Children's playgrounds need not be linked with the main pavilion as it is usual to provide a separate shelter with lavatories for both sexes. They should be adequately screened from the rest of the ground by a fencing surround, with a good hedge or border of trees and shrubs around the outside of the fence, which, on establishment, may provide shade and windbreak. An opening to the main field section is desirable, so that children may romp freely when team games are not in progress or where organized games can be enjoyed either on separate pitches or by alternative use of portions of the senior pitches.

The advantages to be aimed at, therefore, in grouping facilities appropriately are to effect the maximum economy in the use of space, to facilitate management and maintenance, to ensure reasonable convenience and safety to players, and to reduce constructional costs by keeping approach roads and footpaths, as well as connexions to public services, as short as possible.

In the layout of playing facilities a further point which ought to receive attention wherever practicable is satisfactory orientation for the principal direction of play, so that the minimum nuisance from the sun is experienced when sighting balls in mid air. The author knows of no more thorough investigation of this subject than that carried out by the late Brigadier-General P. Maud, a former Chairman of the Grounds and Layout Committee of The National Playing Fields Association, and therefore thinks he can do no better than to reprint the substance of the original thesis as it appeared in *Playing Fields*, Vol. iv. No. 3, dated April 1937, along with a copy of the original diagram Fig. 26.

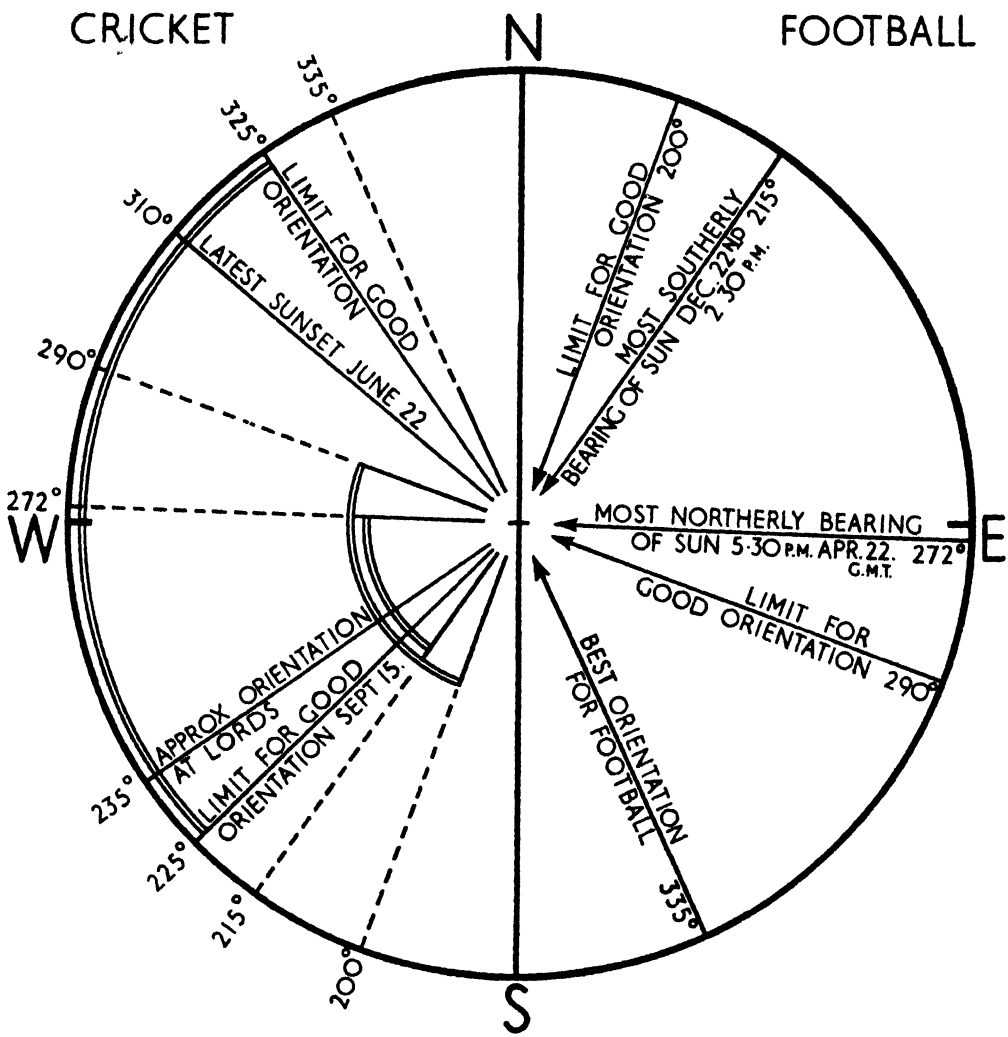


FIG. 26. ORIENTATION DIAGRAM REFERRED TO IN BRIG.-GEN. MAUD'S THESIS

THE ORIENTATION OF GAMES PITCHES

By Brig.-Gen. P. Maud, C.M.G., C.B.E.

The object of the proper orientation of games pitches is to avoid siting the pitches so that the principal line of play will be in the direction of the sun when the latter is sufficiently low to interfere with players sighting the ball in or near that direction.

This is an important factor in planning the layout of a playing field.

The principal games affected are cricket, lawn tennis, and football. At hockey the ball keeps low and orientation is less important. In cases, therefore, where all the

PLATE 8. *Power-Shovel, or Mechanical Navvy, excavating soil and filling large Dumper-Wagons for transport of material for make-up of low areas*

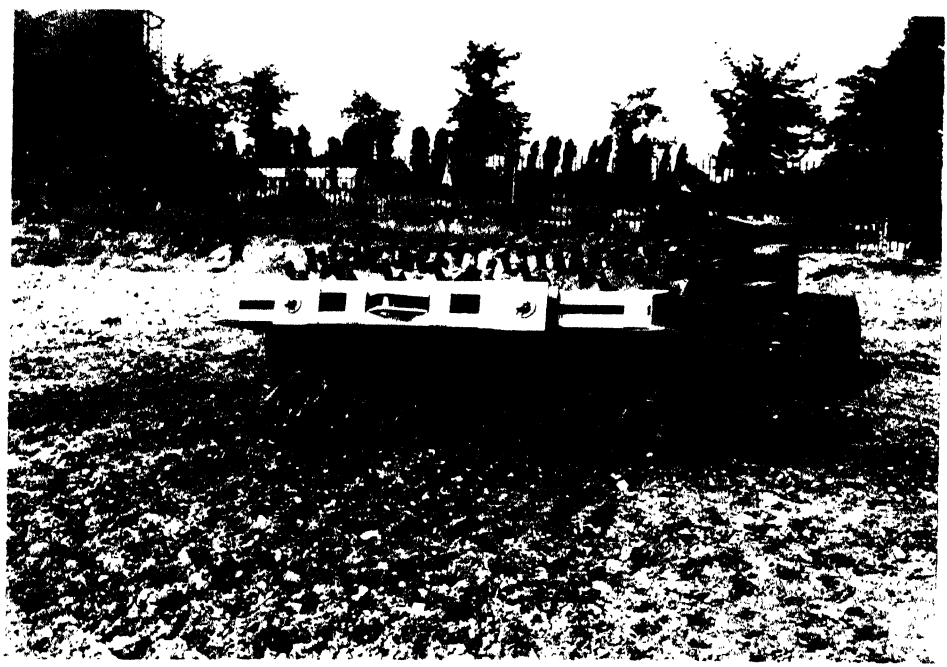


PLATE 9. *Compaction by Sheepsfoot Roller*

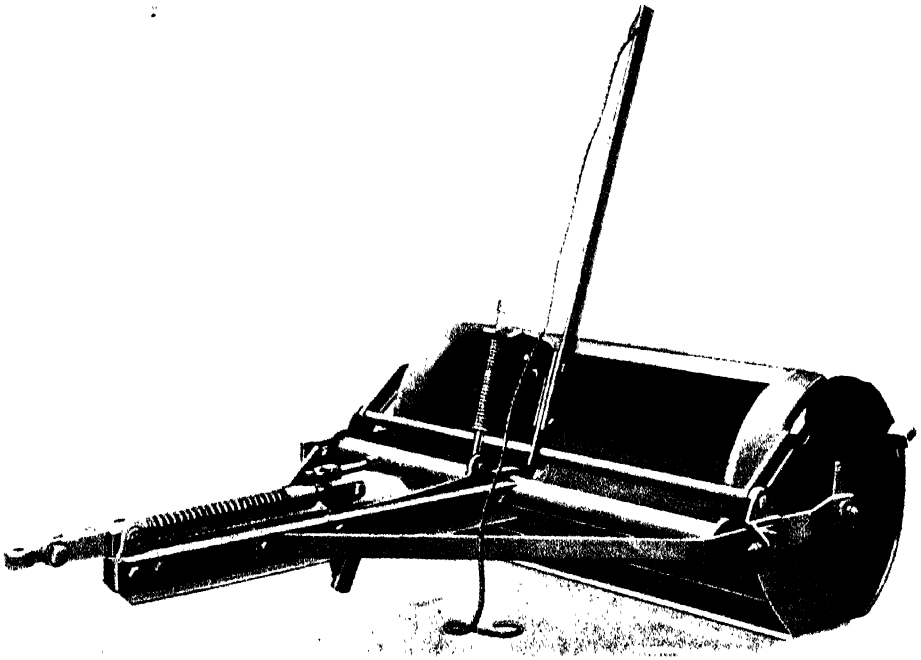


PLATE 10. *Rotary Earth Scoop useful for shallow excavations, moved over short distances*

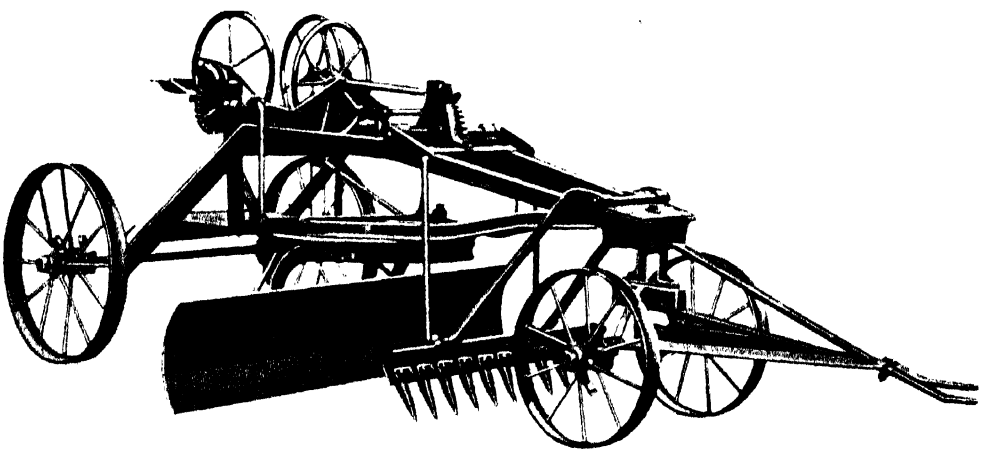


PLATE 11. *An 'Allen-Oxford' Blade Grader for final surface grading. Can be used with or without Scarifier according to condition of soil*

winter pitches cannot be given a good orientation, preference should be given to football.

The principal line of play at cricket is the direction of the wicket and good orientation is a great advantage to the batsman, bowler, wicket-keeper, and those fielding 'fine' to the wicket. Other fieldsmen cannot, of course, be provided for.

At tennis the principal line of play is the direction of the length of the court and players are perhaps more affected than at any other game.

It is, generally speaking, not difficult to provide a good orientation for this game as the court is comparatively short, and two courts side by side occupy, roughly speaking, a square area, so that they can be sited in the same rectangular space in either of two directions. Further, courts can be sited side by side or end on, although the latter arrangement is rather extravagant of space and not so easy for maintenance.

At football, the principal line of play is the direction of the length of the pitch, and good orientation is important for all players. Cases where players have to sight a high ball, the direction of which is more than slightly oblique to the principal line of play, cannot, of course be provided for.

There are many small grounds, the shape of which dictates the orientation of cricket and football pitches, and if good orientation runs counter to that dictation, it must be subordinated to the more important considerations of fitting in the cricket table with adequate outfield boundaries without sacrificing an extra football or hockey pitch, and of giving the latter pitches adequate dimensions.

Again, if the field is on a pronounced slope and extensive levelling is not practicable, good orientation of football pitches and cricket tables may have to give way to the more important considerations of siting the principal line of play parallel with the contours instead of up and down the slope.

In most cases, however, of playing fields which are fairly level and well balanced in shape, one is presented with the alternatives of siting the pitches with the principal line of play either parallel to or at right angles to one or more straight boundaries. It is often quite obvious which of these alternatives will provide the best orientation, but cases occur where none of the alternatives presented provide a really good orientation and it then becomes necessary to decide which is the best. This can only be done by a somewhat detailed analysis of the extent to which the altitude and direction of the sun throughout the season will interfere with the sighting of the ball, when it is in the principal line of play, during that period of the day which is the most important for play in the case of each game.

Such an analysis must obviously raise some debatable questions, e.g., the amount of obliquity to the direction of the sun, and its lowest elevation which will not seriously affect players, and the part of the day which should be taken as the most important for each game.

For the purpose of reaching definite conclusions the writer has been obliged to make assumptions on these points with which some readers may not agree. So far as

is known, this question of orientation has never been systematically dealt with, and it has therefore been necessary in making these assumptions to rely on personal experience and that of a few players who have been consulted.

In these circumstances, the writer is particularly anxious not to be dogmatic, although it is not easy to avoid appearing so in this analysis.

In the following investigation it is assumed that the playing field has a low horizon all round, which, for the purpose of orienting pitches, is the most difficult case. Any high buildings or belt of trees which obscures the sun as it sinks will ease the situation, and should be taken into consideration.

For the different data regarding the sun, i.e. its bearing and altitude at various times and on various dates, I am greatly indebted to the Reverend A. J. Potter, of the Royal Geographical Society, who worked them out. The only work of reference from which these data can be obtained is the Davis Tables to work with which a familiarity is necessary which the writer does not possess.

The diagram (Fig. 26) applies to both cricket and football. To avoid confusion, the bearings referring to cricket are drawn as radii and are described on the left half of the diagram.

The bearings referring to football are drawn as diameters and are described on the right half of the diagram.

CRICKET

The season is taken as being from 1st May to 15th September.

The times referred to are British Summer Time (B.S.T.).

Little cricket is played before 10.30 a.m. by which time the lowest altitude of the sun is (at the end of the season) 33° and is increasing. Morning cricket need not, therefore, be considered.

It is not easy to determine the time in the afternoon when the sun has sunk sufficiently low, and is sufficiently near the principal line of play to interfere with the players who should be considered.

Mr. P. F. Warner (now Sir Pelham Warner) says that, during the many seasons he played at Lords, he does not remember while batting ever being inconvenienced by the sun when it was over the pavilion, straight behind the bowler's arm, but that he does remember occasions near the end of the season in the late afternoon by the time that the sun had got round to near mid-off, it had sunk sufficiently low to induce him to pull the peak of his cap down.

At Lords the direction of the wicket (which is perpendicular to the pavilion front) is approximately 235° true bearing (10° north of south-west) and on August 31st (which may be taken as the end of the first-class cricket season) the sun is at bearing 235° at 3.50 p.m. when its altitude is 35°. It is at bearing 250° near mid-off at 4.50 p.m. and its altitude is then at 26°.

This gives one a line to work on as regards the altitude of the sun when it first becomes troublesome.

The season on public playing fields, however, extends a fortnight later than that of first-class cricket, and play does not cease at 6.30 p.m. An orientation must therefore be avoided which places the principal line of play at a bearing less than say 15° more than the bearing of the sun at its latest time of setting during the season, which is at midsummer, when it sets at bearing 310°. This gives the limit for good orientation in the north-west as 325°.

The south-western limit for good orientation may be taken as 15° *less* than the bearing of the sun of September 15th, when it has sunk to an altitude of 26°. The latter bearing is 240° and the bearing 15° *less* is 225°, at which bearing its altitude is 33° and the time is about 3.15 p.m.

Bearing 225° for September 15th gives about as good an orientation as bearing 235° does for August 31st (at Lords) and may be taken as the south-western limit for good orientation on public playing fields. Orientations within the 100° arc from 225° to 325° should therefore be avoided, and the further an orientation enters this arc from either side the worse it will be.

LAWN TENNIS

This game is played on hard courts all the year round and on grass courts during the same season as cricket. It is played all day until sunset.

The north-eastern limit for good orientation may be taken as the same as that for cricket, i.e. 325°. The south-western limit for grass courts may also be taken as that for cricket, i.e. 225°, although owing to the greater altitude at which tennis players have to sight the ball, that limit will not give quite as good an orientation as it does at cricket. This disadvantage would, however, only be apparent towards the end of the season.

For hard courts, with their winter play, the limit for good orientation should be a smaller bearing than 225° and it might, with advantage, be fixed as the same as that for football—200° at which bearing the sun is as high as about 30° altitude—March 1st and October 11th.

FOOTBALL

The season is taken as being from September 1st to April 30th.

The times referred to are Greenwich Mean Time (G.M.T.) until the change to British Summer Time (B.S.T.) and thereafter are B.S.T.

It may be taken that during the whole of this season, except for morning matches for night workers, morning 'organised' school games and boys' school matches on Saturday mornings, the earliest normal time for commencing a match is 2.30 p.m. G.M.T. and the latest normal time for finishing a match is 5.30 p.m. G.M.T. or B.S.T.

During this season the bearing of the sun at 2.30 p.m. is at its smallest at mid-winter at 215°. At 5.30 p.m. it is greatest on April 21st—the last day on which G.M.T. can occur, with a bearing of 272°.

As the highest altitude of the sun between these times, and for the whole of this period, is never high enough not to interfere with players sighting a high ball in its direction it is clear that any orientation within this arc 215° to 272° must be considered as unsatisfactory and the further the orientation can be removed therefrom the better it will be.

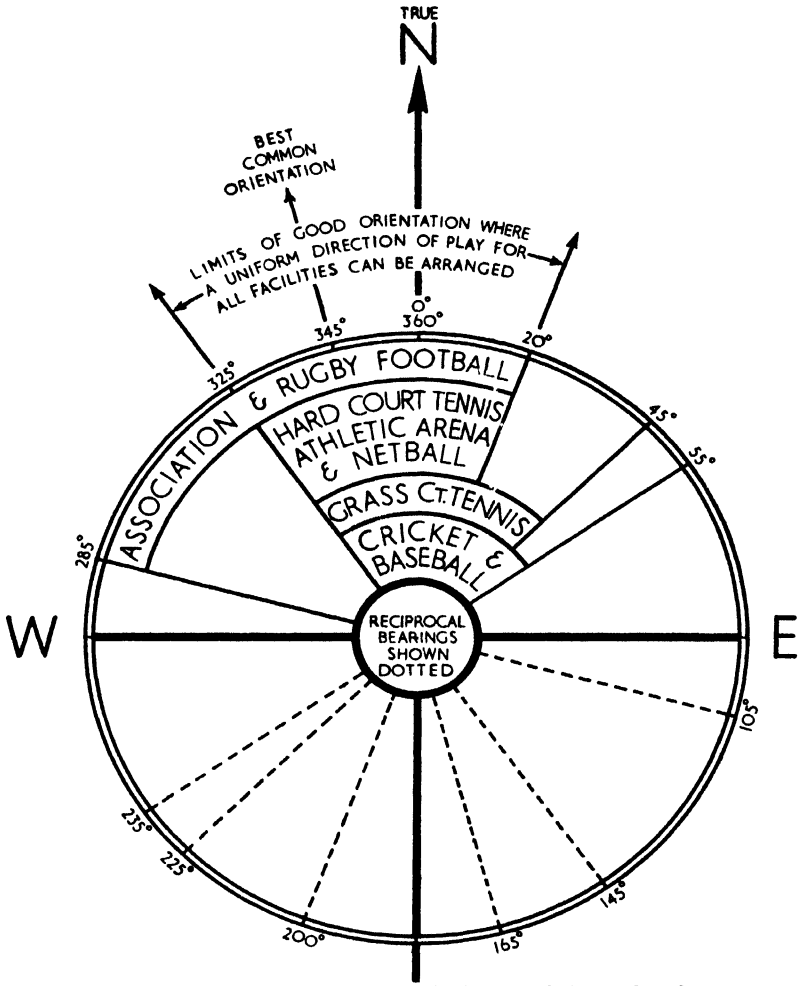
To provide what may be called a good orientation it is considered that the bearing of the principal line of play should not be less than about 15° from this arc and for simplicity the limits for good orientation are taken as bearing 200° south of west and bearing 290° north of west.

It must be appreciated that with orientations of 200° or 290° the worst cases, which are when the sun is only about 15° from the principal line of play, will only occur at the actual commencement of a match starting at 2.30 p.m. at mid-winter or at the actual end of a match terminating at 5.30 p.m. on the last day on which G.M.T. can fall—April 21st—and throughout the course of the matches and at all other times and dates within the assumed limits the situation will be better.

The arc which must be provided for good orientation is thus 200° to 290°—which happens to be a right angle—and it seems remarkable how much further *west* of north a good orientation can be secured than *east* of north—70° as against 20°. The best orientation for football is perpendicular to the central bearing of the arc to be avoided, i.e. 335°.

It will be seen that in cases where cricket tables and football pitches have to be given the same orientation the arc to be avoided for good orientation must extend from the south western limit for football, 200°, to the north western limit for cricket, 325°—an arc of 125°. This leaves an arc of only 55° for what is described in this article as good orientation. It is also clear that good orientation for both games cannot be secured in cases where it is necessary to site a cricket table and a football pitch at right angles to each other.

Fig. 27 is based on a later diagram drawn up by Brig.-Gen. Maud after further investigation to clarify the recommendations made in respect of individual games and to permit easier reference. It will be noted that greater latitude is permitted by this later diagram. These recommendations are, of course, based on solar conditions experienced for the latitude of Greenwich, England, and have proved generally satisfactory over the major parts of England, although it will be appreciated that some adjustment is advisable for more northern latitudes. The farther north the lower will be the sun's altitude, but the days are longer in summer and shorter in winter. It has already been observed that cricket is less in demand on public playing fields in the north, and that football is played throughout the greater part of the year. It would probably be best therefore in the north of England and Scotland to limit the arc of bearings for games pitches to that between



FOR THE PURPOSE OF THIS CHART THE SEASONS FOR THE VARIOUS RECREATIONAL FACILITIES HAVE BEEN TAKEN AS FOLLOWS :-

ASSOCIATION FOOTBALL
RUGBY FOOTBALL . . . . . FROM SEPT. 1ST TO APRIL 30TH

HARD COURT TENNIS
ATHLETIC ARENA
NETBALL . . . . . ALL THE YEAR ROUND

CRICKET
BASEBALL
GRASS COURT TENNIS . . . . FROM MAY 1ST TO SEPT. 15TH

HOCKEY PITCHES MAY BE SITED IN ANY DIRECTION AS IN THIS GAME THE BALL SELDOM RISES SUFFICIENTLY FOR THE SUN TO BE A NUISANCE

FIG. 27. REVISED ORIENTATION DIAGRAM BASED ON BRIG.-GEN. MAUD'S REVISIONS TO HIS ORIGINAL SUGGESTIONS

north-west and north-east, the western half being preferable for winter and the eastern half for summer games.

Applying these principles of planning. The illustrations which follow are intended to show at a glance how the foregoing recommendations have been applied in the layout of playing facilities on fields of varying shape and size. They are not offered as examples of landscape design, but merely as an endeavour to show how the facilities desired could be accommodated in the

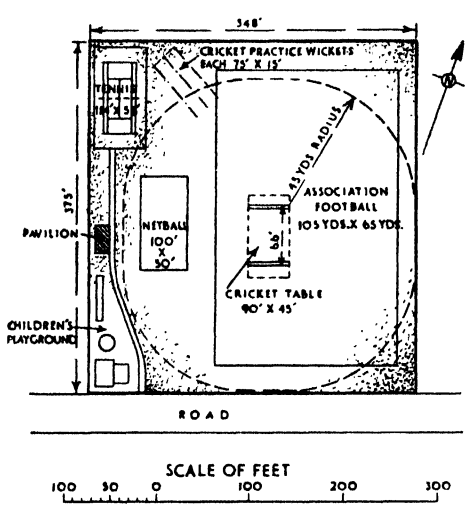


FIG. 28. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 3 ACRES

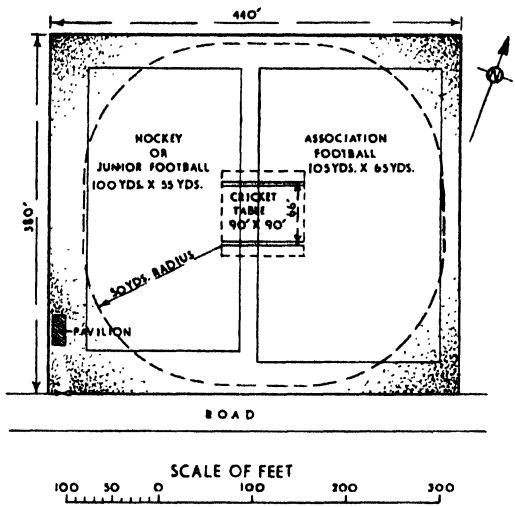


FIG. 29. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 4 ACRES

space available to the best advantage. The aim of the Association is to encourage the maximum number of the population who can, to actively participate in the playing of games and other forms of health-giving physical recreation rather than to promote landscape effects for passive admiration, or encouraging opportunities to induce the bulk of the population to become mere spectators. Experience has shown an acute shortage of playing space in all parts of the country and accordingly the Association cannot look with favour on land acquired for use as playing fields being laid out extravagantly to achieve elaborate ornamental effects at the expense of playing space.

Figs. 28 to 35 show suggestions for the layout of rectangular fields ranging in size from 3 to 18 acres approximately. The type of games facilities planned are those in most popular demand and the drawings show at a glance the

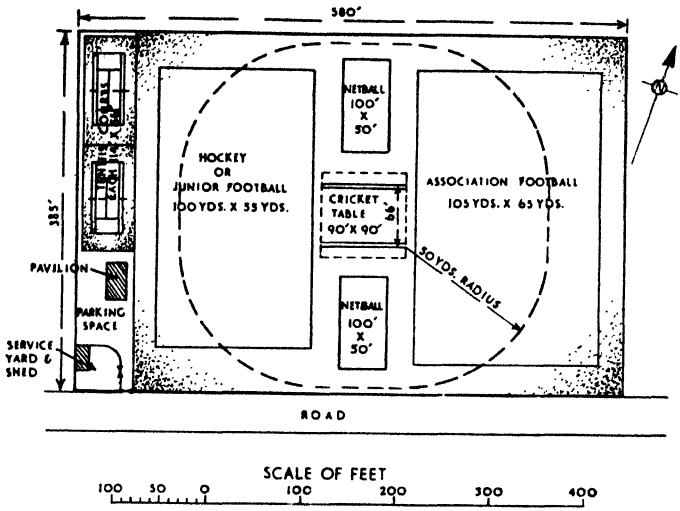


FIG. 30. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 5 ACRES

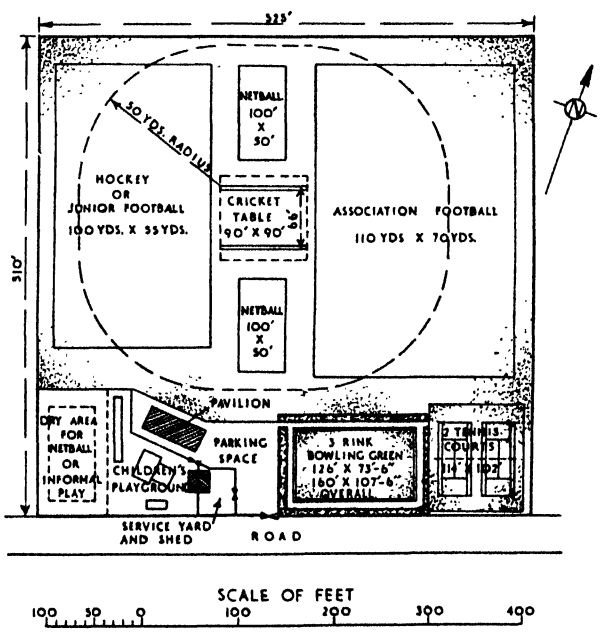


FIG. 31. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 6 ACRES

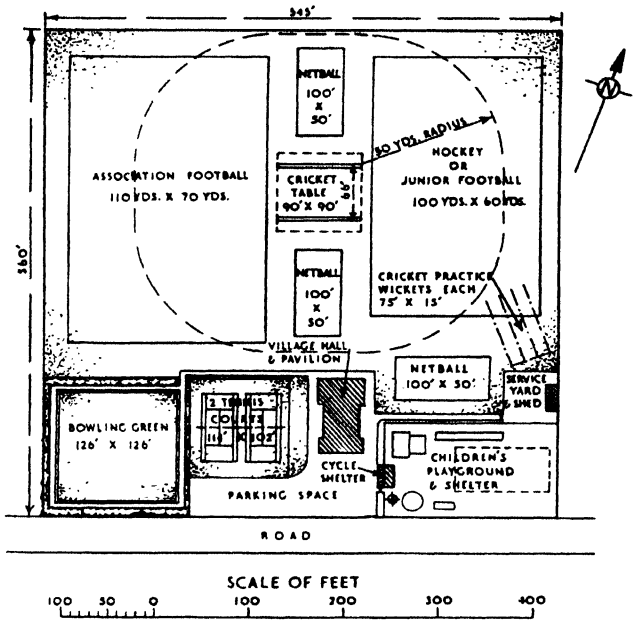


FIG. 32. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 7 ACRES

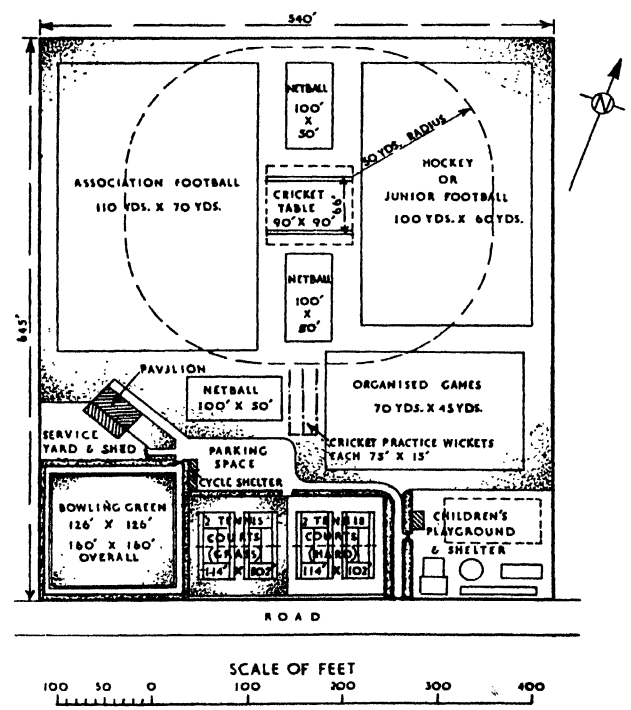


FIG. 33. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 8 ACRES

maximum development practicable in relation to the area of land available. From a study of these diagrams it should be evident that a field of 6 acres of good shape, proportions, and contours is just about the minimum that may be developed to provide facilities for football, cricket, and hockey with some limited space for bowls, tennis, and children's amusements.

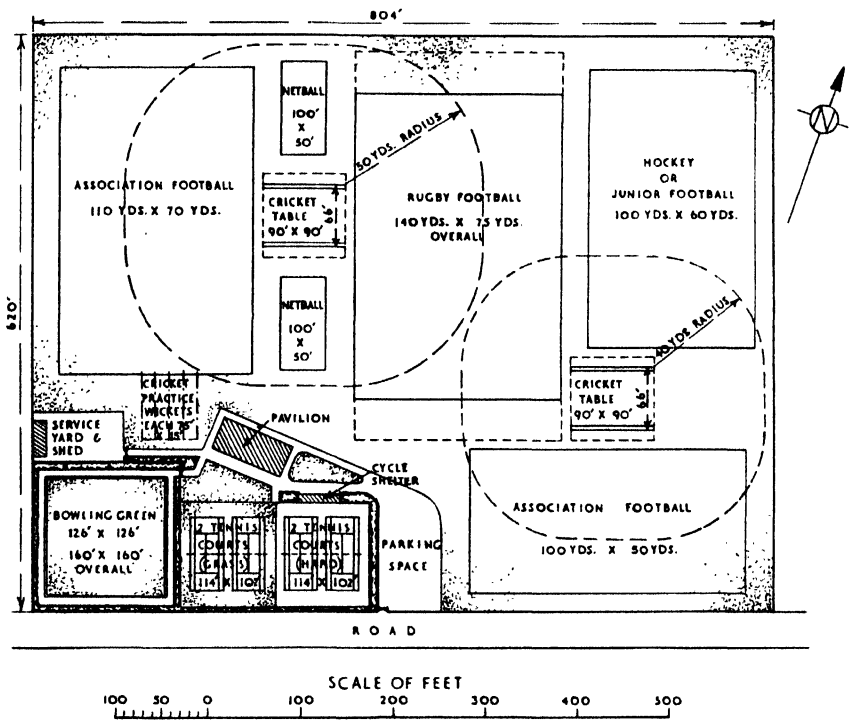


FIG. 34. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 11½ ACRES

It is hoped these drawings may be useful to promoters of sports and welfare schemes in clarifying the principles of layout previously outlined, and also may assist them in gauging more accurately the area of ground required to meet the demand for any particular scheme of playing facilities. Of course, where the ground slopes severely or is of an undulating character and major levelling is essential to reduce surface gradients to acceptable limits for play, due allowance must be made in computing the area of land required for space lost in tailing out the boundaries of the cut and fill to sufficiently stable slopes in accordance with the angle of repose of the materials excavated.

The influence of local peculiarities on the layout arrangements may be appreciated from the following examples:

Fig. 36 is a type of layout problem that is frequently met in village schemes. In this case a field of 5 acres was available attached to the existing

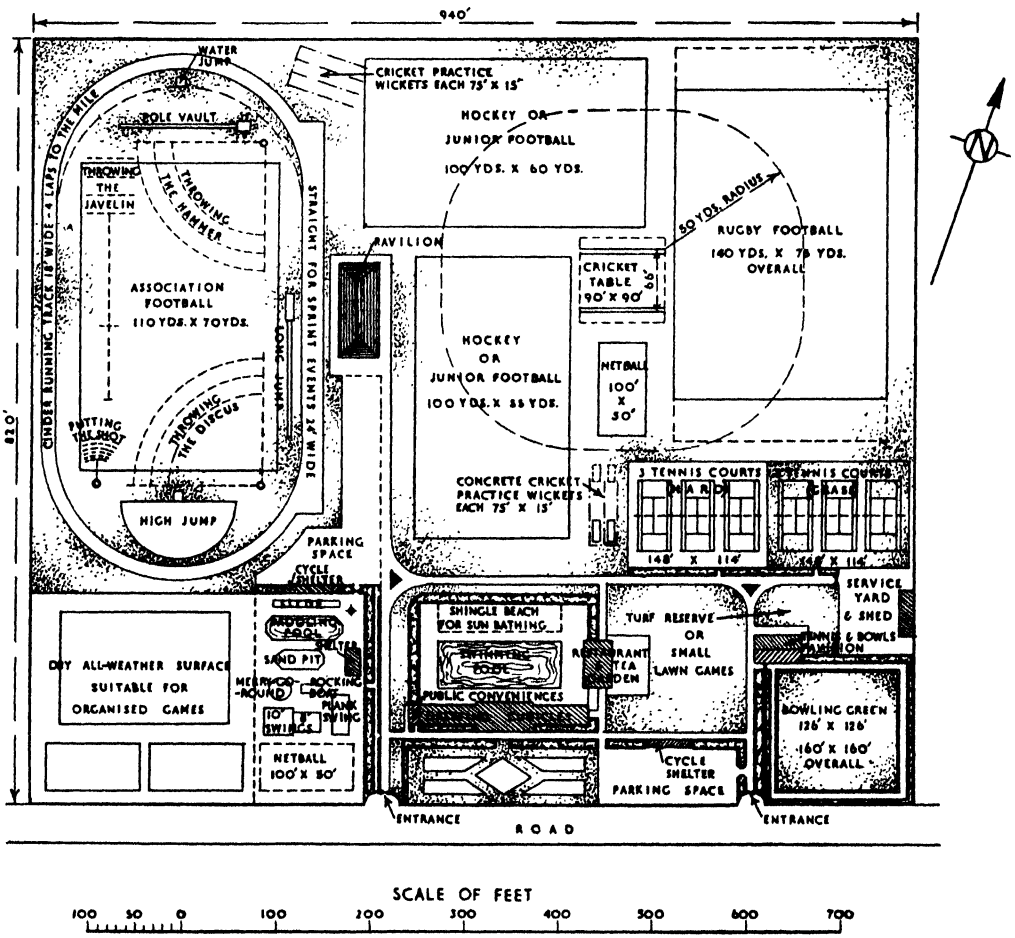


FIG. 35. LAYOUT FOR RECTANGULAR SPACE OF APPROX. 17¾ ACRES

village hall and it was desired to provide scope for cricket, football, hockey, and similar field games as well as tennis, bowls, and a children's playground. It will be noticed that, apart from the limited area, further difficulties existed through the awkward shape of the field, the position of the village hall, and the variety of games facilities demanded. As a consequence the team-games area had to be seriously curtailed and only one winter-games

pitch was possible of a size which could be used alternatively for hockey or football. To allow a reasonably safe boundary for senior cricket the cricket table had to be reduced to the minimum width, leaving room on the eastern section of the outfield for a children's organized games pitch or for general practice purposes.

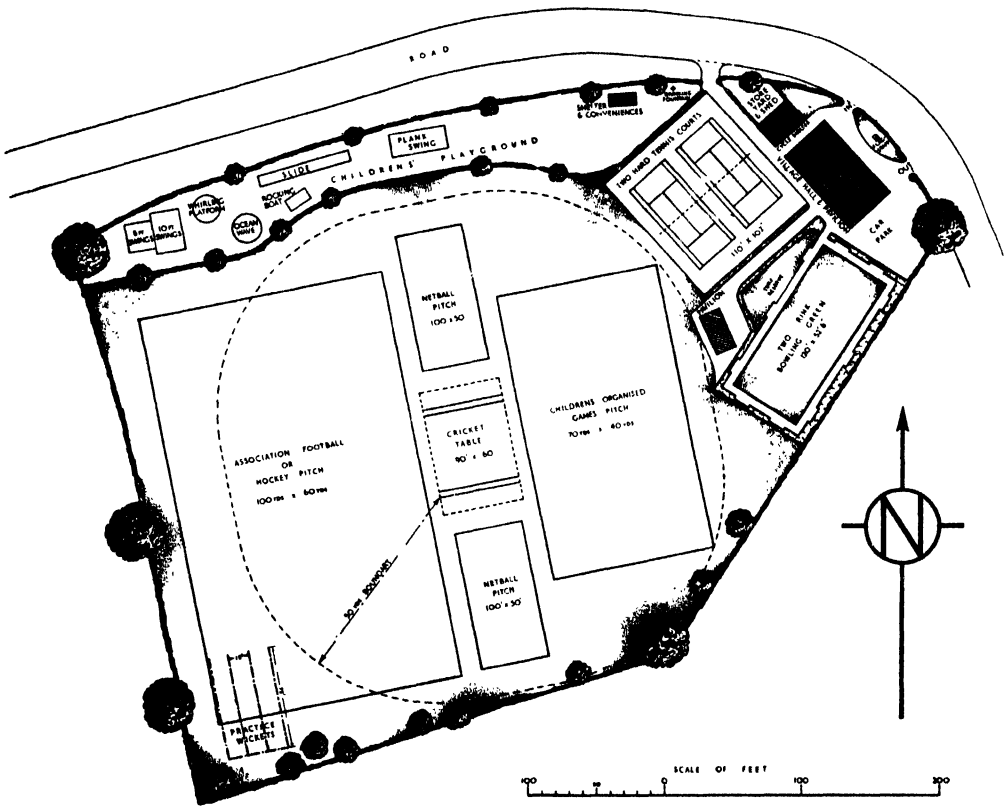


FIG. 36. A SMALL VILLAGE PLAYING FIELD OF APPROX. 5 ACRES

A small two-rinked bowling green was sited immediately to the south-west of the village hall, and it was possible to arrange for an additional half-rink in width to allow the position of rinks to be moved slightly from time to time as recommended to reduce wear on the ends of the green. A good turf nursery is also suggested, which is a useful provision where space will permit, as one-way greens, subject to severe play in certain climatic circumstances, may wear rapidly at the ends and an adequate reserve of established turf for renovation purposes is very desirable.

The only space available for tennis was to the north-west of the bowling green and the orientation had to be accepted a few degrees beyond the desirable limits, but the sun is only likely to be troublesome in this case when play is continued into the late summer evenings. For normal hours of play throughout the year no serious sighting troubles should be experienced.

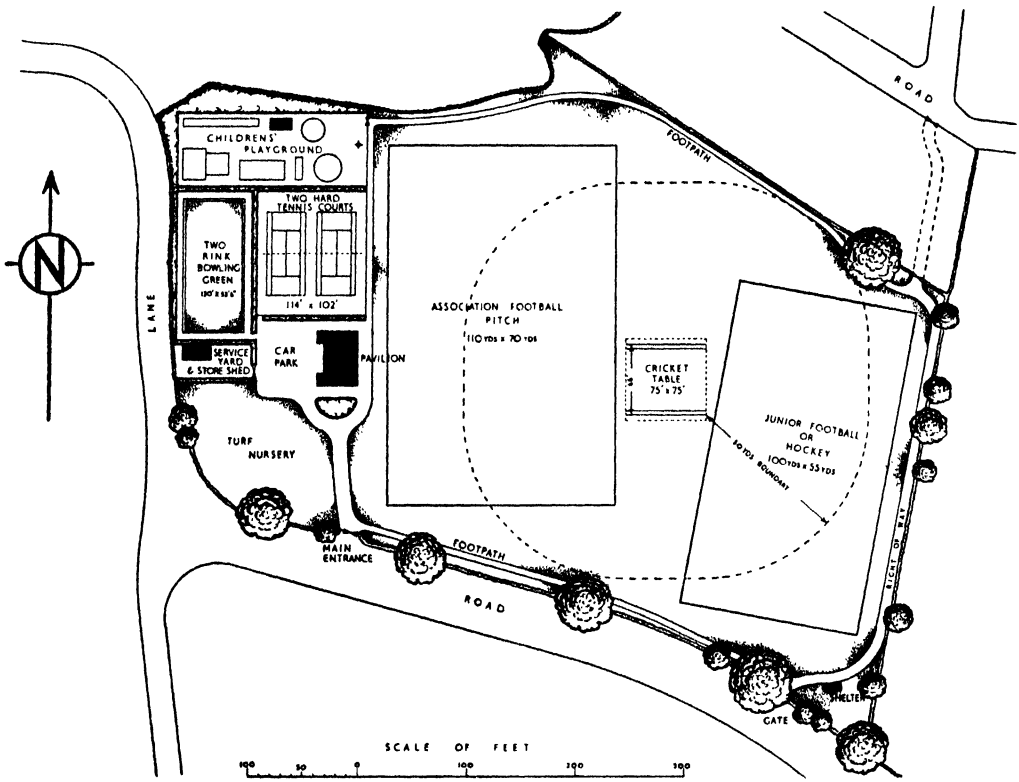


FIG. 37. VILLAGE PLAYING FIELD OF APPROX. 6¼ ACRES

An area for a children's dry-surface playground has been arranged along the northern boundary with sufficient space to accommodate a selection of popular amusements, shelter, conveniences, and drinking-fountain as well as a small area for other general impromptu play. Note how the inner boundary of the playground has been curved to provide an adequate outfield for senior cricket.

It will be noted also that netball if desired can be played on areas to the north and south of the cricket table, where play on grass is acceptable. Recent demands for hard netball courts if pressed too far may lead to a

curtailment of facilities for this excellent and popular game as in many cases the ground is not available for separate features of this type. Alternative use of hard tennis courts for netball is often adopted by using different coloured markings. Under normal climatic conditions, however, a well-drained grass area can provide opportunities for netball when other arrangements are inexpedient or impracticable.

Other essential amenities include car park, cycle shed, store yard, and organized games pavilion. The latter is sited to command a good view of the cricket table although, unfortunately, a western aspect was unavoidable if the grouping of all facilities and buildings was to be arranged to avoid excessive expenditure on access paths and connexions to public services where necessary to their function and maintenance.

Fig. 37 shows another village scheme of just over 6 acres in extent. Here again the influence of shape on the internal arrangements can be fully appreciated by comparing with the layout on Fig. 31. The improved arrangement of the main turf section for team games as a result of the greater area available than in the previous example is clearly evident, and it is possible to allow a good senior football pitch as well as a separate pitch for junior football or hockey to the west and east of the cricket table, despite some loss of ground necessary through diversion of a right of way and the provision of footpaths to link existing entrances.

Note how the dimensions and siting of the cricket table have been determined to allow the best orientation, reasonable marginal clearances, and an adequate boundary for senior matches. The improved facilities for organized team games rather curtails the allowance for children's playground but some free space could be allowed here, if desired, by reducing the number of mechanical amusements. Otherwise the plan is self explanatory.

Fig. 38 shows a scheme of approximately 18 acres designed to meet the requirements of a large urban district. A site had to be reserved for a community centre and two opposite main entrances had to be linked up with the minimum disturbance to the arrangement of the games areas required. An independent athletic arena was requested with some limited accommodation for spectators and this of course further influenced the scope of the organized-games facilities that could be included in the scheme. It will be noted also that a considerable amount of major levelling was necessary and this resulted in an appreciable amount of ground being reserved along the boundaries for the necessary banks formed by the cut and fill.

A comparison of this plan with that shown in Fig. 35 is interesting as

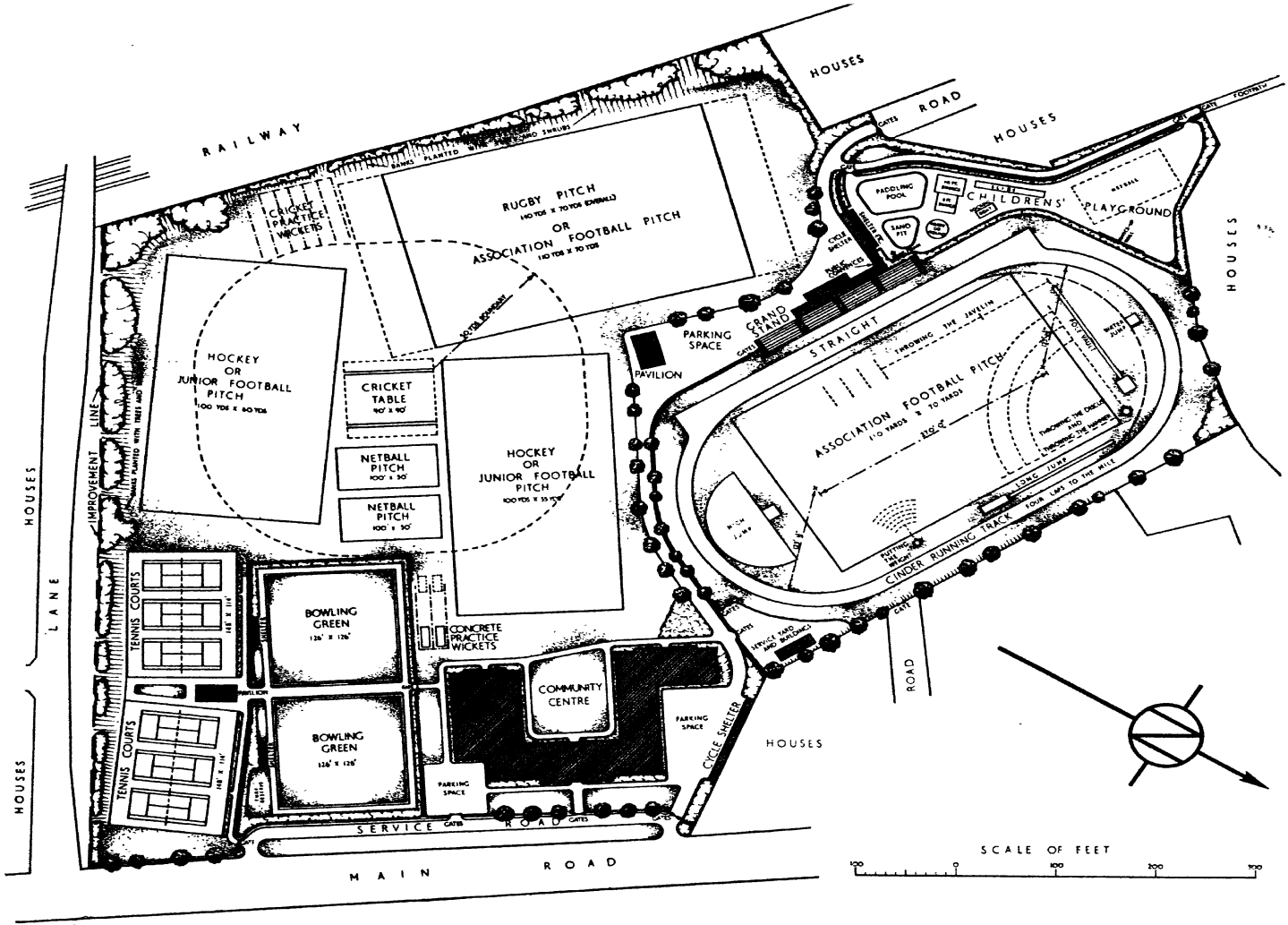


FIG. 38. AN 18-ACRE PLAYING FIELD

showing the effect of irregular boundaries and other local characteristics on the layout. Note how some of the games pitches can only be fitted in with a poor orientation but these have been designated for junior football or hockey. At first glance it may appear that cricket would be better in the transverse direction to that shown, but on reference to the orientation chart, Fig. 27, it will be seen that the direction east of north is more within the permissible arc of bearings than west of north in this case.

The orientation of the running track, while not ideal, is the best that could be arranged without waste of space. The straight is shown 24 feet wide for six lanes and the circuit 16 feet wide for four lanes. If, however, spectators can be restricted to the south-east side the circuit can be increased to 24 feet in width.

The remaining features of the scheme can be easily identified and all the usual amenities essential to the convenience of users and to efficient operation and maintenance have been included to the extent that space will permit.

Fig. 39 shows a 16-acre school site including 12 acres of playing fields and a typical arrangement of facilities to suit the needs of a secondary school is indicated. Note how the dimensions of pitches and courts have been scaled down to meet the physical capacity of younger players, and the suggested training area for athletics which would be a valuable feature on all principal school fields where space will permit.

Fig. 40 shows a layout for a 30-acre scheme to meet the needs of a newly planned township. The ground sloped rather severely from north-east to south-west and a considerable reduction in gradients by major levelling had to be allowed for. The planning of the residential area surrounding the site resulted in a number of entrances and it was essential that some effective arrangement should be made to prevent pedestrians taking short cuts across the playing field to reach other parts of the estate. A margin along the boundaries was therefore allowed to be developed as a parkway linking up the various entrances and forming an effective barrier to unnecessary traffic on the playing area. This parkway development would also permit the adjustment between the finished levels of the playing field and the surrounding ground to be effected in an attractive manner, and when established would provide a pleasing background to the field.

The junior organized-games field is planned in the south-west salient adjacent to the sites selected for the new schools, and in the southern corner there is a dry-surfaced equipped playground suggested just inside the entrance from the school. A further dry-playground area, if required, could

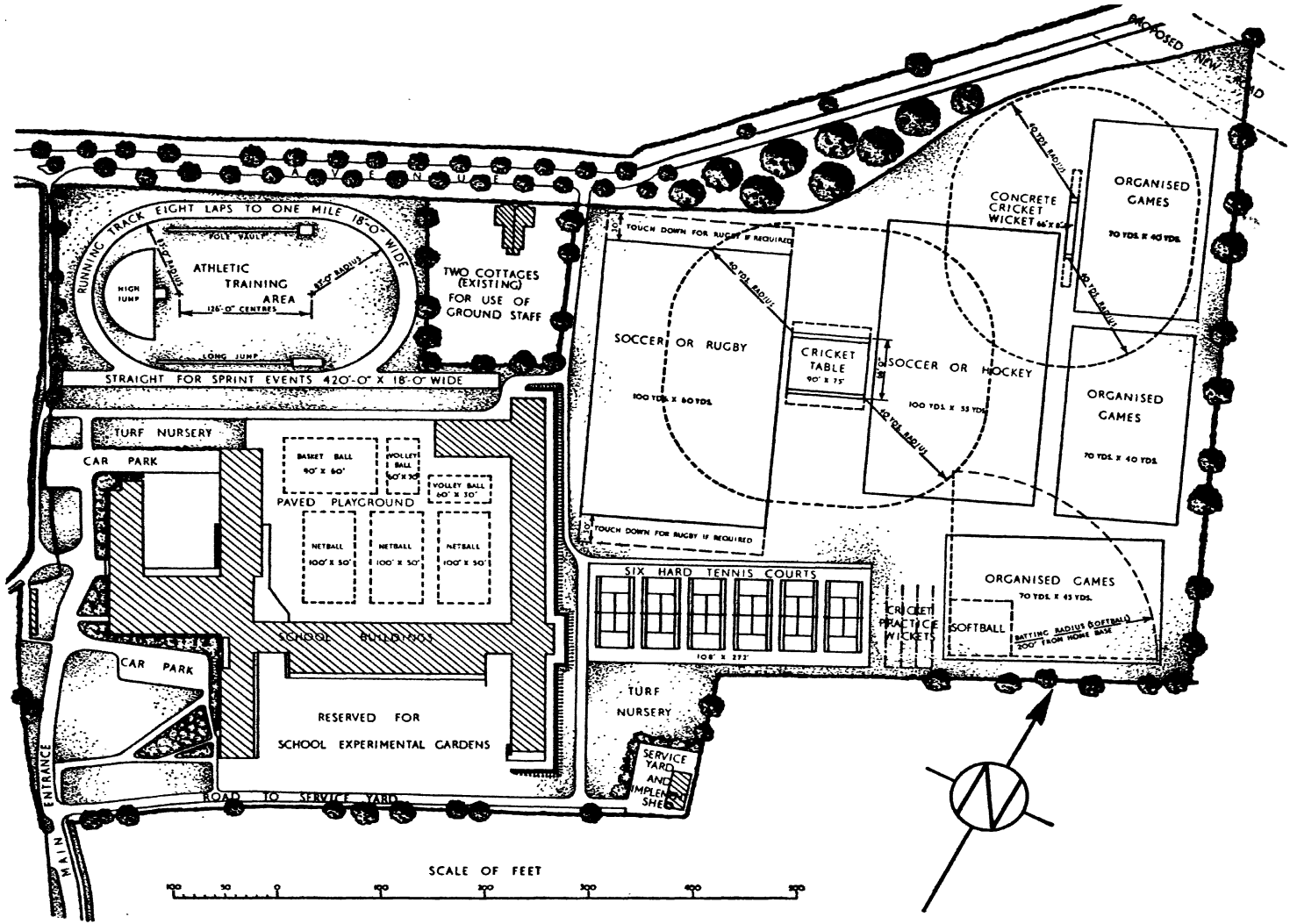


FIG. 39. A 16-ACRE SCHOOL SITE WITH A 12-ACRE PLAYING FIELD LAYOUT

PLATE 12. *A 'Barber-Greene' Ditcher at work excavating trench for land drains*

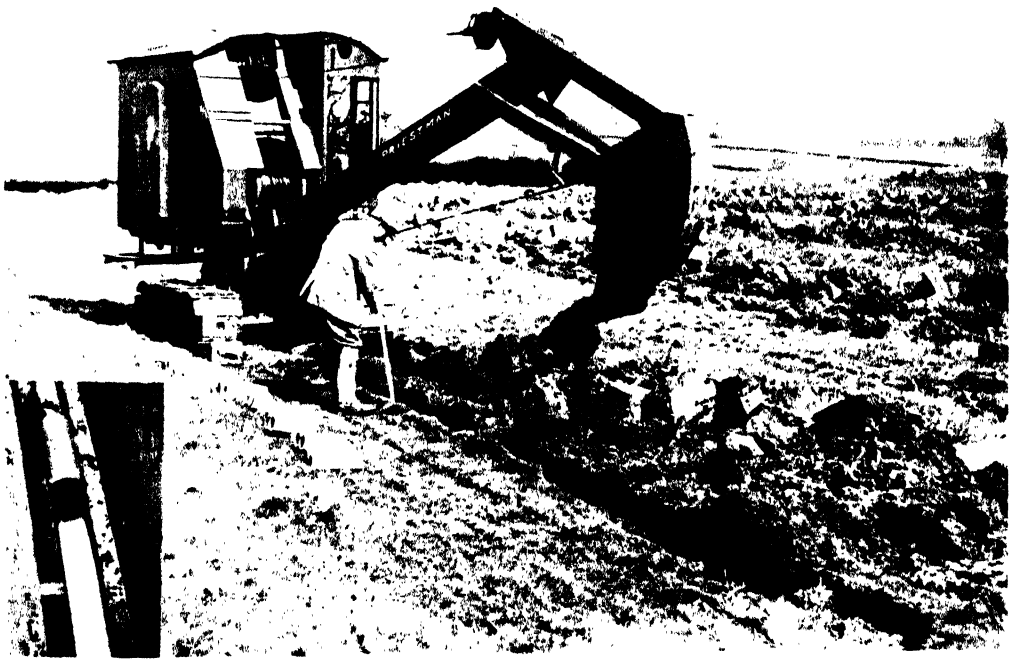


PLATE 13. *A Priestman 'Cub' Excavator with special 'Teredo' shovel cutting narrow trenches for land drains*

PLATE 14. *A Back-Acting Excavator on trenching work*

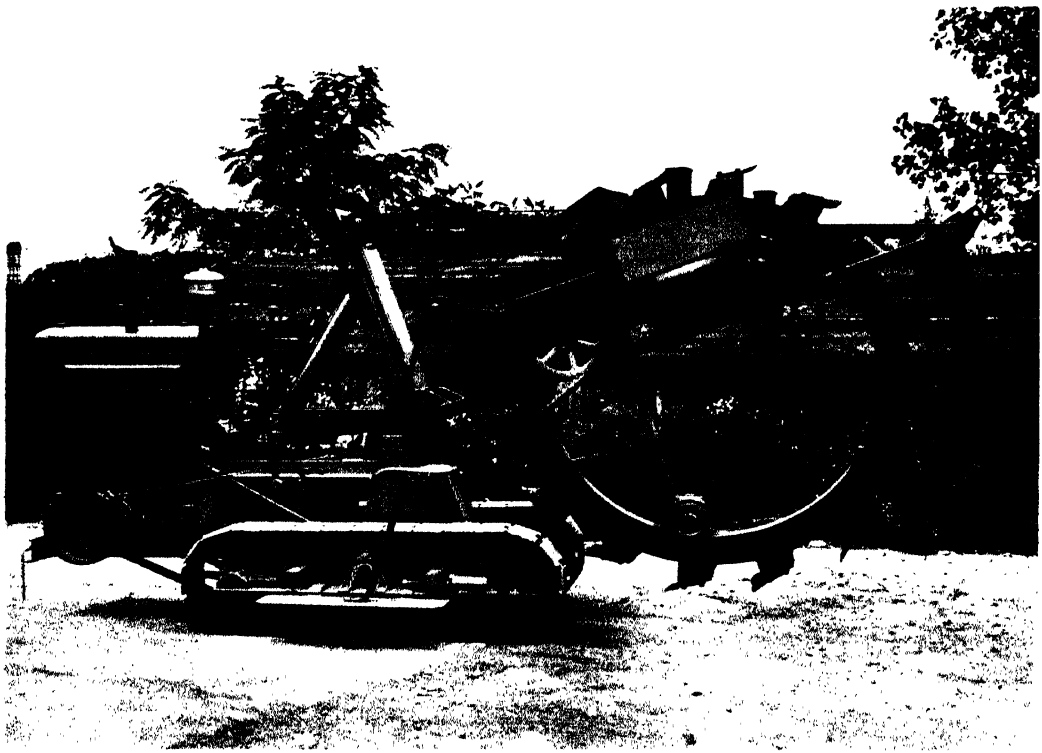


PLATE 15. *A 'Cleveland' Bucket-Wheel Trencher for shallow land drainage work*

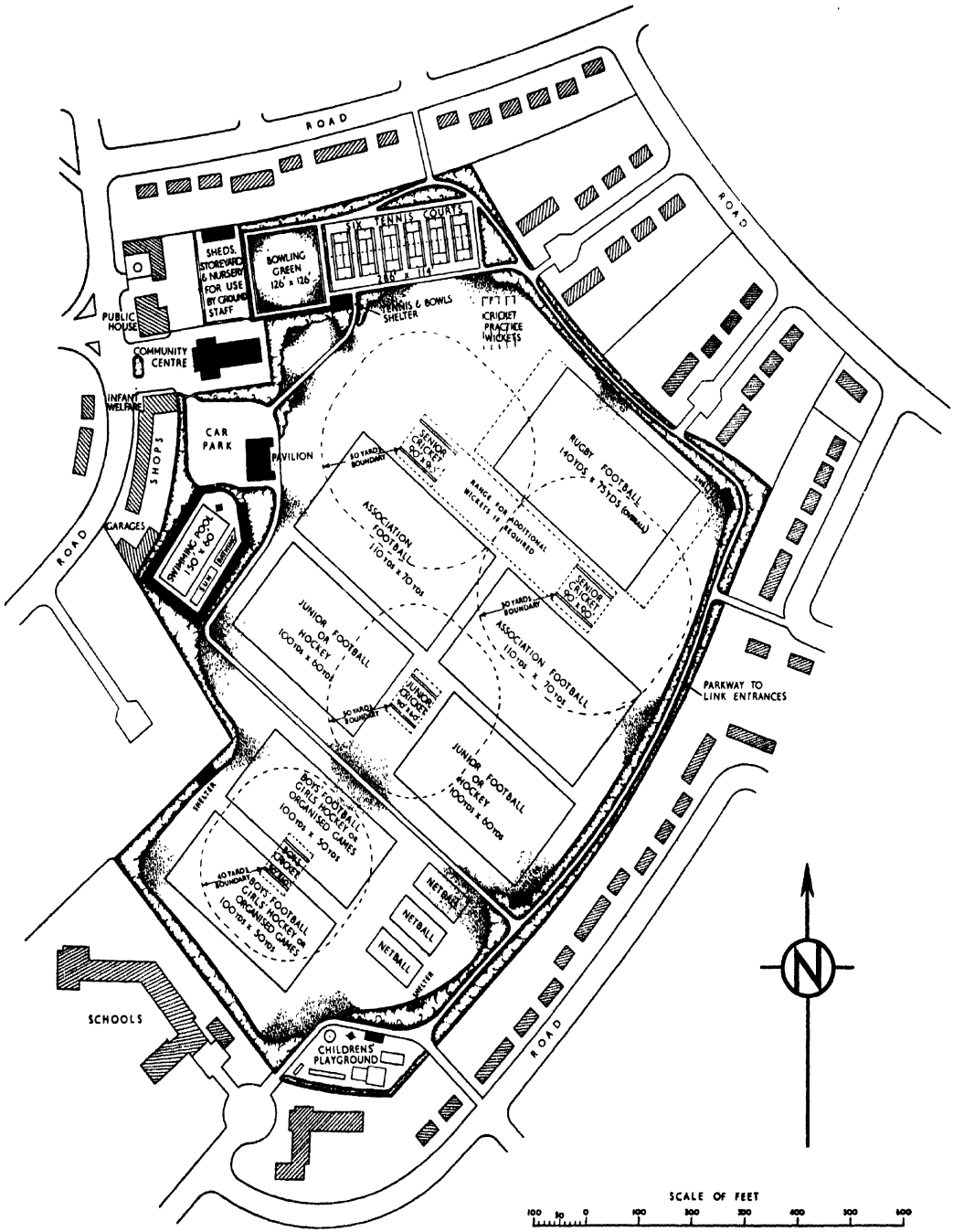


FIG. 40. PROPOSAL FOR A 30-ACRE PLAYING FIELD FOR A NEW TOWN

be accommodated on the section of the playing field where the netball pitches are shown and the hard surface would be available for unorganized play when not required for netball.

The site for the community centre was already fixed, and projected rather awkwardly into the playing field. The tennis courts, bowling green, swimming pool, store yard, and nursery for ground-staff, pavilions, &c., are all grouped as conveniently as possible near to the community centre so that essential service connexions may be economically made.

In view of the serious cost of excavation it was proposed to accept finished surface gradients of 1 in 40 from north-east to south-west and it will be seen that it has been possible in this case to arrange the direction of play for all winter-games pitches well within the limits of good orientation and at the same time transverse to the main fall of the ground.

Plate 1 is taken from a photograph of a model based on a design prepared by the Parks Department of Leeds for their new King George's Field. The site is approximately 72 acres in extent and there is a fine old manor house and outbuildings which it is proposed to adapt for pavilion and other social purposes. An endeavour is also made to preserve as many of the trees as possible around the house and the model shows how effectively this will be accomplished.

To the north of the main entrance drive is the organized-games area with several pitches for football and hockey and 8 cricket tables. To the south are 12 tennis courts and 3 bowling greens with a pavilion and ornamental lawn forming a terrace between.

The children's equipped playground is attractively hidden away among the trees to the west of the drive as it approaches the house. The irregular area to the west of the bowling green is projected as a putting course and the larger field in the south-west is intended as a grass area for children. The small area immediately north of the putting course is intended as a nursery reserve, and on the field immediately to the north of this an athletic arena is proposed, complete with cycle track. The remainder of the estate is planned for general unorganized play and relaxation.

The whole scheme is well conceived and should greatly enhance the opportunities for outdoor physical recreation in the area. With the exception of the athletic arena all the playing facilities have a good orientation, but the siting of the arena had to be decided by the shape of the ground if existing amenities were not to be seriously disturbed.

It would be better if the bowling greens could be moved slightly south

and west to give a little greater clearance from adjoining trees, otherwise the removal of those overhanging the playing area may have to be considered in the interest of economic maintenance and surface stability.

Planning the children's playground. There are many diverse opinions as to the best method of designing play-areas for young children. Unfortunately, however, too many approach the problem with purely aesthetic aims resulting in types of layouts which show a lack of appreciation of the main purpose of a playground, namely, to provide space where children can play freely in comfort and safety with the minimum of restraint.

The achievement of pleasing landscape or simple architectural effects is desirable but, where allowed to predominate in the planning of these areas, may result in an extravagant use of space, impose severe restrictions on the activities of the youngsters, or aggravate to a considerable degree the problems of supervision and maintenance. Whatever the form of treatment adopted to beautify the area, it is seldom possible to conceal wholly the harsh mechanical outlines of the popular playground features. Some planners like to disperse the various pieces of equipment over a wide area linked by a path winding round a central grass plot and screening each individual appliance by planting banks or borders of trees and shrubs around the safety clearance area allowed. It is claimed that this garden-like arrangement is more inviting to the child and that the dispersed and hidden appliances offer many pleasant surprises as he wanders round the playground. Consequently he must derive more enjoyment from such an arrangement than where all the attractions are immediately visible on entering the ground. Surely it cannot be seriously contended that this element of surprise can be sustained after the child has become familiar with the layout. Admittedly this type of plan can be made to look most attractive on paper and probably on the ground for a short while after establishment. In practice, however, it will be found that, if the playground is used by children to the extent it should be, it will be extremely difficult to confine their general traffic to the footpath. They will most certainly take the shortest route from one plaything to another, frequently crossing and recrossing the central lawn. As a consequence, an ever-increasing number of tracks are formed across the turf which finally develops into a mud patch more depressing in appearance than any tar macadam or similarly paved area so frequently condemned as unsightly.

We have also noticed proposals for setting swings and other mechanical attractions on raised platforms or terraces of stone slabs to squared random

or crazy design, approached by stone steps, flanked by walled recesses planted with shrubs. Or again, the play-area has been laid out as a lawn with stepping-stones across the turf leading to the various playthings, including a sand-pit set in a leafy bower. Charming settings no doubt for posing, well behaved, and immaculate little 'Lord Fauntleroy', but hardly the environment where healthy and vigorous youngsters can work off that abundant energy which is their natural heritage. Quite apart from this, however, it is obvious that such designs take no account of the seasonal influences, nor the added complexities and increased costs of maintenance and supervision.

When examining elaborate schemes of this nature the writer cannot help reflecting on his own early boyhood. At the top of the house was a large, well-lighted, airy attic which was set aside for the younger members of the family and their playmates during the damp, dreary Scottish winter months. No attempt was made to instil in us a sense of artistic appreciation by any particular mode of interior decoration or furnishing. Here we were permitted to assemble what we thought fit to collect from the junk discarded by the grown-ups; old clothes, old furniture, old packing cases, and similar odd-ments. Here were no outside standards imposed on us so we could value highly the valueless, find abundant uses for the useless, and even sense some order in disorder. The general appearance of our domain would probably have displeased the sensibilities of the aesthete with his singularly poised standard of perception, but with our unfettered imaginations there was no limit to the scenes we could conjure up from the apparent chaos, nor the mighty figures who deigned to consort with us.

The spacious bare floors and unadorned walls might appear cold and uninviting to the informed material senses. To us they were capable of the most wonderful transformations; at one moment the seven seas with limitless horizons over which we sailed with Drake to the Spanish Main, at another the wide open spaces of the woolly west where we shared adventures with Buffalo Bill and other worthies. Again, at other times it was our exclusive stadium or gymnasium, where we boxed, wrestled, or improvized numerous games or contests. In this part of the house we were free from parental discipline and restraint. There was nothing of value to be damaged, and we were far enough away from our elders to be as boisterous as we wished without causing annoyance. We learned to respect the reasons for restraint and discipline on formal occasions when we knew we could escape at the appropriate time to our own sphere of freedom and informality.

Perhaps the reader will excuse this digression which it is hoped bears out the fact that children at play are not greatly influenced by the character

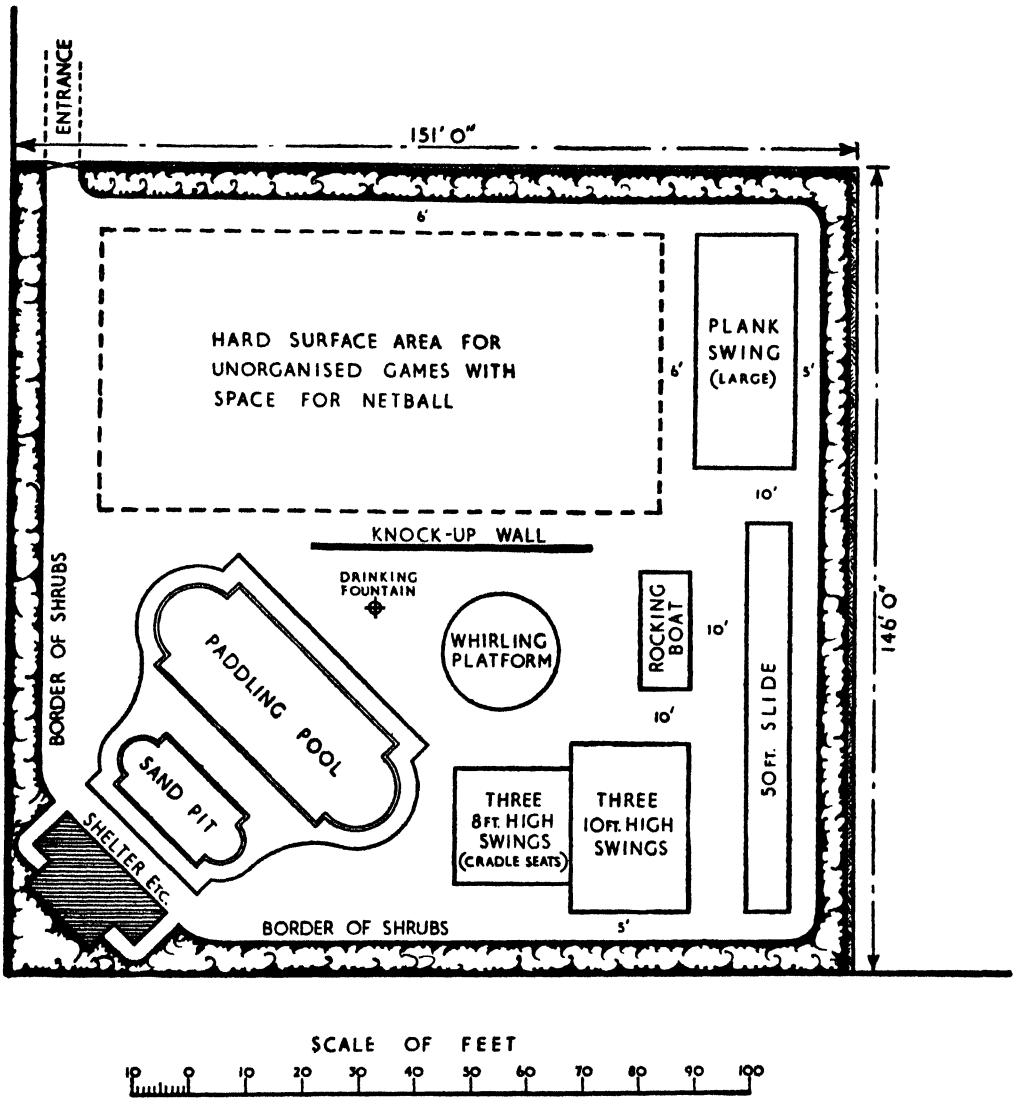


FIG. 41. CHILDREN'S PLAYGROUND OF APPROX. ½ ACRE

of their environment, provided they have the space and equipment they need, and freedom to use them as they wish. Children cannot play freely in highly ornate gardens, and the sooner designers face up to this fact the better it will be for the young, and those who have to watch over them.

The method of layout recommended by The National Playing Fields Association is shown in the diagrams (Figs. 41–4). Any mechanical appliances

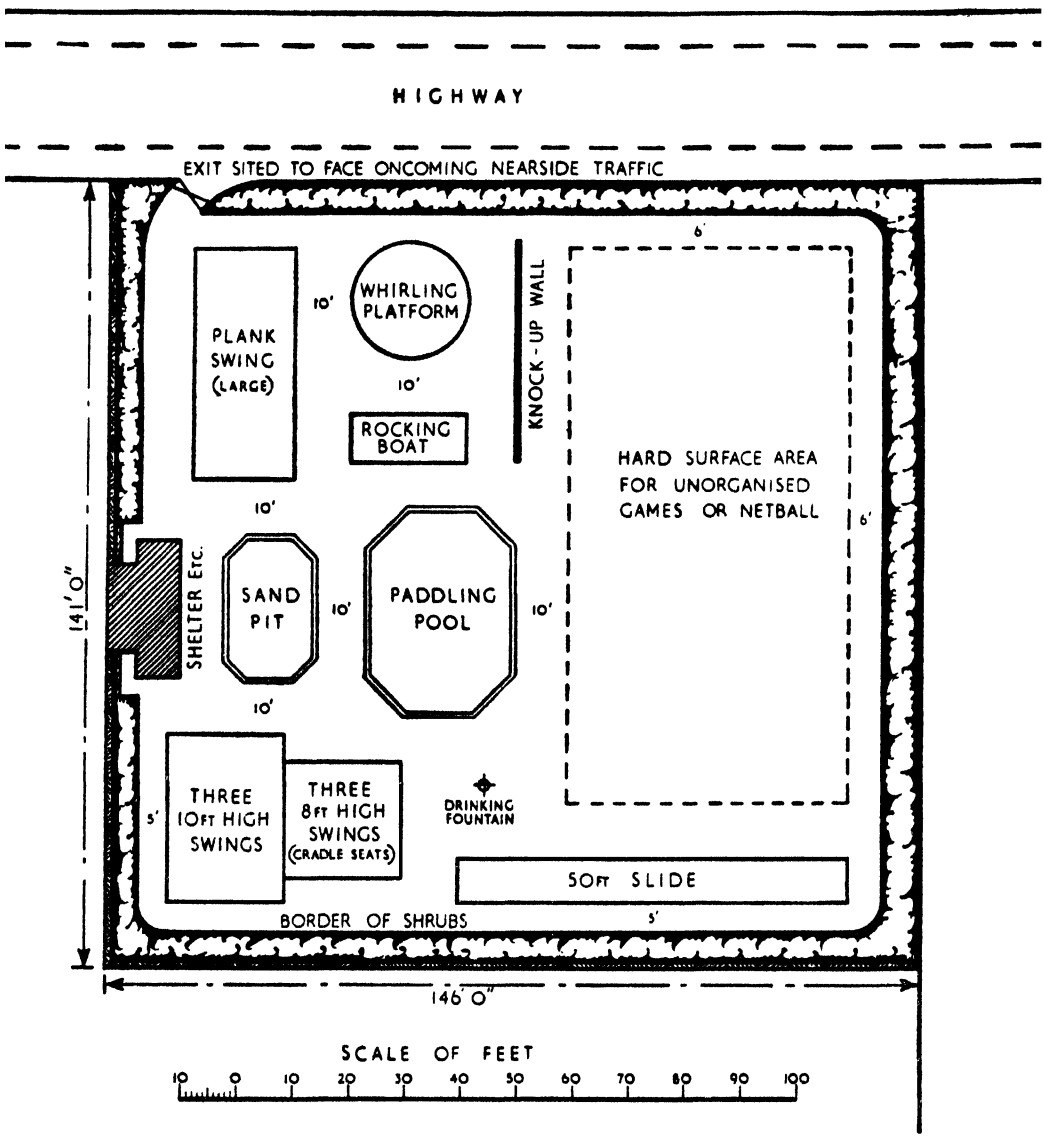


FIG. 42. CHILDREN'S PLAYGROUND OF JUST UNDER ½ ACRE

for the children's amusement are concentrated in the minimum space demanded for safety and to provide room for circulation. There should be also, wherever practicable, sufficient free space adjoining the equipped section

paved with some durable type of highway surfacing capable of being used in all weathers for hop-scotch, roller skating, scooters, and similar pastimes for which the youngsters find the public roadways so eminently suitable despite traffic dangers, in the absence of any convenient alternatives. A

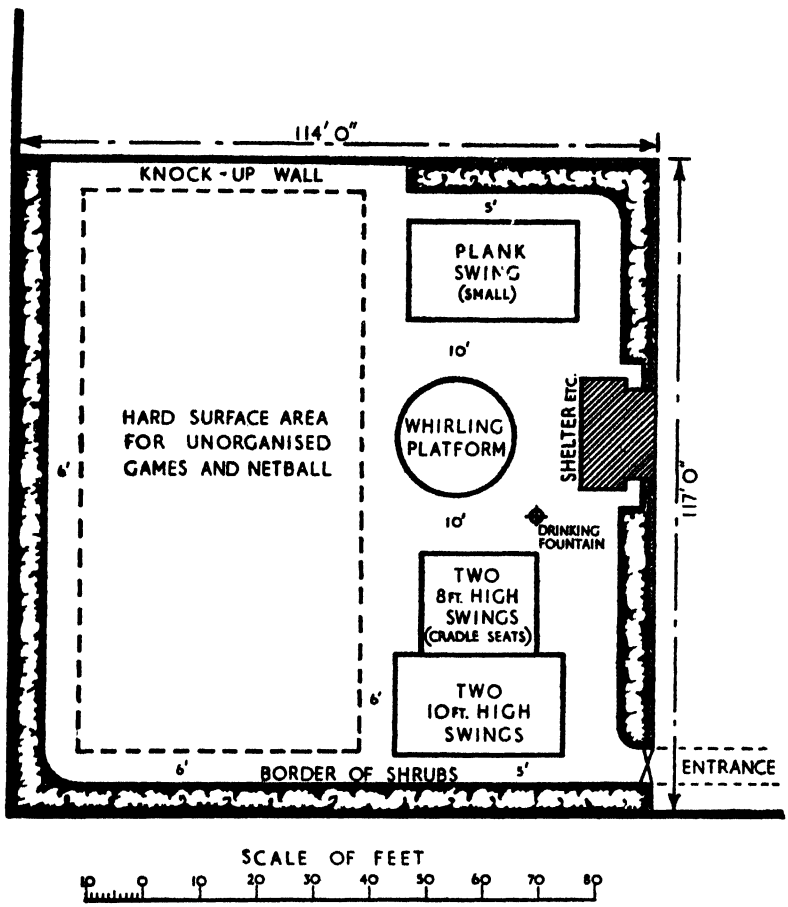


FIG. 43. CHILDREN'S PLAYGROUND OF APPROX. $\frac{3}{10}$ ACRE

knock-up wall of suitable height is also a valuable attraction as it provides facilities for those ball games for which boys and girls will use any convenient gable notwithstanding the risk of damage to windows.

The Association realizes the shortcomings in the appearance of these playgrounds, but contends that space is used to the best advantage and that mothers or others accompanying toddlers can take a seat somewhere on the boundaries and keep an eye on the child without following around. Further,

the type of surfacing suggested will stand up to the severe density of traffic with the minimum of maintenance, and the children's activities are in no way impaired by changing surface conditions.

It will be noticed that ornamental planning is confined to the boundaries

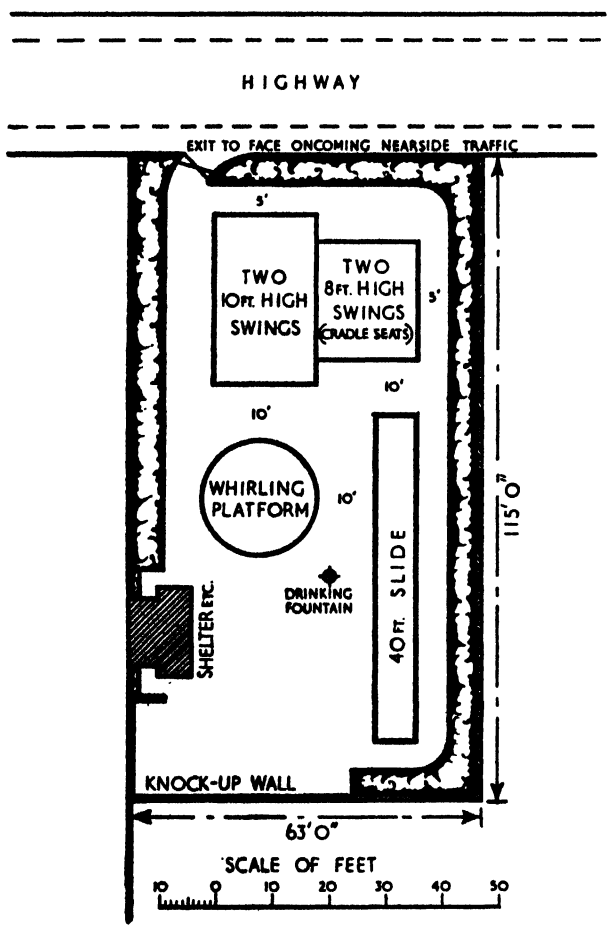


FIG. 44. CHILDREN'S PLAYGROUND OF APPROX. $\frac{1}{8}$ ACRE

where borders of suitable trees and shrubs or a good evergreen hedge may provide an effective screen, background, or wind-break.

Entrances from the public highway should be recessed in such a manner that children leaving the ground must face the oncoming nearside traffic and the gates should be of the self-closing type, so that an impetuous exit is prevented. Where these arrangements are impracticable, rail barriers should be erected on the edge of the footpath just outside the entrance.

Figs. 41 to 44 show suggestions for laying out rectangular play spaces for children, varying from $\frac{1}{6}$ to $\frac{1}{2}$ acre in extent. The outline for each mechanical appliance represents the safety clearance area required. Some planners consider that the safety clearances may be contiguous without any marginal allowances, but the Association considers that wherever possible a 10-foot margin should be allowed between adjacent safety clearance areas, and 5 feet along the boundaries, to provide adequate space for circulation.

It will be evident that on areas less than $\frac{1}{4}$ acre in extent it is difficult to arrange suitable space for unorganized play while providing at the same time a small section of mechanical amusements.

Note the way entrances to a main traffic road are recessed so that it is impossible to leave the ground without looking in the direction of oncoming traffic. Gates should always open inwards and be of the self-closing type. Where such arrangements are not expedient barrier rails should be erected on the edge of the footpath outside the entrance, extending a distance of 10 feet at least each side of the entrance.

IV

THE CONSTRUCTION OF PLAYING FIELDS

Site clearing. Before any development can be proceeded with the area to be utilized must be first cleared of all obstructions, trees, shrubs, and any detrimental vegetable matter. Every care must be taken to ensure that clearance is carried out to a sufficient depth, especially where only slight surface adjustments and no major levelling are necessary to produce contours or gradients reasonably good for games.

Any buildings or structures which have to be demolished should have their foundations removed to a depth of at least 18 inches below the finished ground level. Trees, shrubs, and undergrowth removed must have their roots completely grubbed up so that subsequent cultural or maintenance operations may not be impeded in any way. The surface soil should be freely workable to a depth of at least 9 inches.

The wide range of modern power equipment available has added greatly to the economy and efficiency of site-clearing operations. It is, however, essentially work for a specialist, especially where large trees have to be dealt with. After trees, hedges, and undergrowth have been pulled, any roots remaining should be torn out by means of heavy rippers, and all detrimental matter brought to the surface by these operations collected and burnt or removed from the site.

Large holes or depressions left after trees, hedges, or other obstructions have been removed, should preferably be filled in with clean, hard, dry material to within 9 inches of the surface, and the remaining depth completed with good soil. If this is too costly, and the filling is done with soil from the site, then this must be deposited in layers not exceeding 6 inches in depth, and well rammed between each layer, until the desired level is obtained. Even so, some slight adjustment may be necessary later as a result of subsidence if the filling is carried out to any appreciable depth.

Filling ponds. Where important playing-areas are sited over old ponds which have to be filled in, all the implications of such action should be carefully considered. If the ponds have been formed as receptacles for the flow of surface-water or subsoil drainage, alternative methods must be adopted to cope with these aspects before any filling is commenced. In many cases, however, they are merely shallow ponds for watering cattle, or the

results of old soil workings such as gravel or claypits, whose subsequent filling may not involve any disturbance of existing drainage arrangements.

It is, of course, essential that any water in the ponds should be drained away or pumped out and the soft mud removed before any filling is commenced. The filling should, wherever practicable, be of hard, clean, dry material (such as broken brick, stone, or concrete hardcore, clinker or gravel) put down in layers and well consolidated to within 9 inches of the final surface levels, the remaining depth to be filled in with good soil. Where this procedure is not followed there is likely to be serious trouble in after years through settlement, and the resultant instability of the playing surface may cause considerable annoyance and risk of injury to players.

Soil conservation. A good layer of vegetable top-soil is essential to the surface of a playing field if a vigorous turf sward is to be established and maintained for organized games. This may appear to be a very elementary observation yet it is surprising how often the point is completely overlooked in these days of mechanical efficiency where all the emphasis is on speedy construction. It may be expedient in many branches of engineering construction to treat the soil as inert matter, but such an assumption in landscape or sports-ground development is likely at a later date to prove troublesome, if not disastrous. The organic and bacterial content of the surface soil exerts a strong influence on all aspects of turf culture, and it is therefore most important to ensure that whatever may be the constructional operation proposed, no top-soil is lost or buried.

In grading or levelling, it is very desirable that the constructional formation should conform as closely as possible to the geological stratification before it was disturbed. This is advisable not only from the point of view of encouraging a healthy, vigorous growth of grass, but also in the interests of surface stability. There is generally a marked difference in the plasticity of surface soils and subsoils, and where these are put down in a different order from their natural occurrence, the reaction under rolling is likely to be unusually variable, and the maintenance of uniform surface gradients so essential to good play becomes extremely difficult.

Where major levelling is involved, it is generally obvious that the top-soil must be removed to a sufficient depth before bulk excavation is commenced, and re-spread evenly over the area after levelling and consolidation have been satisfactorily accomplished. Where, however, the general contours of the site are considered to be in the main reasonably good for games and only surface grading is required to ease out slight local mounds, depressions,

or ridge and furrow, this need for conservation of top-soil may not be appreciated sufficiently. The decision whether or not to remove the top-soil before making the surface adjustment in such cases must depend on the depth of the vegetable soil and the degree of surface regulation required. The depth of the organic soil on the ridges or mounds should be carefully ascertained from inspection pits, and if the amount of surface adjustment necessary is likely to expose the subsoil or leave a depth of less than 4 inches of top-soil on those areas from which the soil has been scraped, then it is advisable to strip the top-soil before grading, and complete the grading adjustments in the subsoil so that when the top-soil is replaced, a satisfactory base for seeding or turfing will be established.

Such considerations, of course, have a marked bearing on constructional costs, but generally prove more economic and efficient in the long run. If the subsoil is exposed or inadequately covered with vegetable soil, it may take years of hard work by repeated applications of organic manures or other soil amendments and frequent reseeding before a suitably vigorous sward can be established. In consequence, there would in all probability be a great loss in playing time through the area being repeatedly out of commission for renovation purposes.

Major levelling and surface grading. A very wide range of improved excavating and earth-moving machinery is now available for site levelling where conditions are suitable for their employment. Crawler and other heavy-powered tractors fitted with bull-dozers, angle-dozers, or scrapers of various sizes, and appropriate types of mechanical diggers, feeding lorries, or dumper wagons, are economical, speedy, and efficient in operation only when employed in the correct circumstances. Many people, however, as a result of casual observation of such machines in operation on many of the larger engineering contracts, have acquired exaggerated ideas as to the all-round uses of such powerful equipment, and seem to think that on any occasion where levelling is required the cheapest and most efficient method is to use a bull-dozer or similar implement.

It is as well therefore to realize that efficiency and economy in all earth-moving operations depends on the choice of the right equipment in relation to the nature and quantity of the materials to be handled, average length of haul between cut and fill, working gradients, space for manœuvring, climatic influences, and, last but not least, the experience and skill of the operator. When it is understood that the most efficient tractors for bull-dozing or excavating weigh from 4½ tons in the smaller sizes to 15 tons in the larger groups,

without the various earth-moving attachments, it will be appreciated that the transport of these machines from one site to another is a costly business, and unless the quantities of earth are sufficiently great, transport charges may have an adverse effect on the construction costs. Furthermore, there are many locations where the limited width of the approach roads to the ground would entirely preclude the employment of such equipment.

In all major levelling for landscape and sports-ground construction, the effect of the equipment used on the structural condition of the soil must be taken into account. When the weights of the machines referred to are considered, it will be readily understood that prolonged and concentrated operational traffic is bound to produce an excessively high degree of compaction in the soil, which, if not counteracted, may set up conditions detrimental to root development and almost certainly lead to serious drainage difficulties. It has been demonstrated in practice that in many cases the soil is compressed by such machines below its natural bulk before disturbance by as much as 20 per cent. in sandy soil and 10 per cent. in loamy and clay soils, and this should be allowed for in determining the finished levels. There have been cases where an appreciable shortage of filling has had to be remedied by importation from external sources, because this factor of compaction had not been adequately considered.

It is therefore essential, where heavy excavating or earth-moving equipment has been used, that any 'panned' effect on the surface of the soil produced by this traffic should be corrected by appropriate tillage, by means of a heavy cultivator or ripper working to a depth of at least 9 inches, before any top-soil is replaced. On plastic soils, this tillage can with advantage, where the cost can be faced, be augmented by suitable amendments to improve the soil texture, such as working in clinker ash, gravel, or coarse sand. Gritty materials of this nature spread to a depth of $1\frac{1}{2}$ to 3 inches and thoroughly incorporated with the upper layer of the subsoil during cultivation will greatly improve the physical character of the subsoil.

Unless the project is sufficiently large, however, the use of any heavy equipment is not likely to prove profitable. For smaller schemes, lighter agricultural tractors operating implements such as rotary scoops, road drags, blade graders, and the like, in addition to the usual range of implements required for cultivation and seeding, will be found quite satisfactory and economical.

These lighter machines do not compact the soil under normal working conditions quite so seriously as the heavier plant and are therefore to be preferred

on playing field construction where the extent and nature of the work is reasonably within their capacity. Nevertheless, even with the use of lighter tackle, if for any reason operations have been unduly prolonged under moist soil conditions, a light cultivation of the subsoil after grading or levelling may be advisable.

Levelling operations and cultivations are most effectively and economically accomplished under optimum soil conditions. In these days of fixed prices, however, output must be a primary consideration in all mechanical operations. Few contractors or plant hirers can afford to have costly machines and operators standing idle if it is at all possible to keep them moving. Consequently work often continues under unfavourable circumstances with the result that the soil structure is seriously impaired and subsequent maintenance problems are made more complex.

The illustration (Plate 2) of a 'Caterpillar' D. 6 tractor and angle-dozer at work clearly indicates how readily the soil becomes puddled by heavy operational traffic when work is pushed forward under very wet conditions. This may not be a great disadvantage in general engineering construction work where a compact inert base is desired, but in landscape and sports-ground work, every effort must be made to keep the soil 'alive' by ensuring a good tilth to a reasonable depth over those sections of the ground where a strong-growing turf is to be established. Wherever practicable, therefore, levelling, grading, or cultural operations should not be permitted when the soil is in a saturated condition.

Under normal conditions, bull-dozers and rotary scoops are most effective and economic in use for hauls up to 100 yards in length. Between 100 and 500 yards haul, tractor-drawn scrapers are usually more suitable. Over this distance, power shovels feeding dumpers or wagons are to be preferred. Much, of course, depends on the quantities involved, the nature of the soil, gradients, mechanical condition of the machines, and the skill of the operators. In many cases the soil may have to be loosened by rooters or scarifiers to obtain the maximum output by tractor-drawn equipment.

Plates 3 and 4 illustrate typical bull-dozing operations. Comparing Plate 4 with Plates 2 and 3 the advantages of working the soil when it is fairly dry will be recognized from the more friable nature of the heap in front of the blade. It is not always practicable, however, on contract work to await optimum conditions and the soil structure of the graded surface should be carefully examined after levelling is completed and a good tilth restored by suitable cultivations where necessary. The normal capacity of soil moved by bull-dozer

blades ranges from 1½ to 3 cubic yards approximately according to the size of the machine employed.

Plates 5, 6, and 7 show excavation operations by means of tractor and scrapers. The cutting edge is lowered into the soil and the scraper towed along until the bowl is filled, the bowl is then raised for transporting the material to the filled area, where the material is ejected by the operation of a sliding tail-gate and spread to shallow depths. Severely compacted or heavy soils require to be loosened by heavy rippers or rooters to facilitate loading. Dry, loose sands do not pile up in the scraper bowls to give capacity loads, and sticky wet soils are not easily discharged from the scrapers so that output may be appreciably affected by the character of the material to be handled quite apart from other local factors.

Scraper units in normal use are as under:

	SCRAPER CAPACITY IN LOOSE CUBIC YARDS	
TRACTOR POWER	STRUCK	HEAPED
35–40 d.b. h.p.	3·5	4
55–65 ,,	6·0	7·5
70–90 ,,	8·0	11·0
110–40 ,,	12·0	15·0

Plate 8 shows a power-shovel feeding dumper-wagons. These shovels of ½ to ¾ cubic yards capacity with adequate wagons or dumpers for transporting the excavated material are normally most efficient where the haulage exceeds 1,500 feet. Of course, maximum economy is only obtained when the transport arrangements are properly balanced to the length of haul so as to eliminate idle time on the part of the excavators or transport units. Attention to maintenance of good travelling conditions for transport between the excavation and filled areas is also important to ensure maximum output.

Plate 9 shows compaction being carried out by Sheepsfoot roller. These rollers are the most efficient means of ensuring maximum compaction in most soils of a more or less cohesive character. They are not so effective on sands, gravels, or crushed rock where no binding material is present. Consolidation should be carried out in layers not exceeding 9 inches thick. The final loose surface layer must be compressed by a suitable flat roller.

In pre-war days much excellent work was done in levelling and grading sports fields by small rotary earth scoops, as shown in Plate 10, with bowl capacities of from ¾ to 1¼ cubic yards. These were drawn by Fordson or similar agricultural tractors and their operation was simply controlled from the seat

of the tractor. A single pull on the rope connected to the trip lever changes the position of the scoop from loading to discharging and vice versa.

Final surface grading is generally effected by towed blade graders as shown in Plate 11. These can be fitted with scarifiers when required for use in compact soils. They can be drawn by Fordson or similar tractors and the considerable variation in the set of the blade both horizontally and vertically, which can be rapidly accomplished by experienced operators as the machine moves over the ground, allows surface irregularities to be eliminated with the utmost efficiency and economy. Where it is possible to carry out grading and levelling with lighter machines and implements much less risk of serious damage to the soil structure is likely to occur, and therefore much less danger of surface drainage difficulties arising.

Turf preservation on pasture land. Where existing pasture land with turf of good quality is to be adapted for sports purposes, but a certain amount of contour regulation is required to effect the surface uniformity necessary for field games, it is often difficult to decide whether to strip the turf, and relay after the surface adjustments have been made, or plough in the turf, cultivate, grade, and reseed the area. If the area to be dealt with is extensive any advantage to be derived from turfing may have to be set aside on account of the much greater cost over seeding. Furthermore, much of the success in turfing will depend on the speed with which the turf can be lifted and relaid. If the degree of surface adjustment necessitates the turf being stacked for any length of time it is likely to be severely checked in growth, and may take some time when relaid to recover, root, and knit sufficiently well to permit play to be commenced. Consequently there may be little gain in time of establishment over that required for turf grown from seed.

Where, however, the general contours are acceptable and only small isolated local mounds or depressions have to be dealt with, then the turf can be raced out in narrow strips, rolled back, the soil adjusted to correct levels by paring off or filling as may be necessary, and the turf rolled back and consolidated. This method of local correction requires great skill, experience, and a practical eye to gauge just how far the treatment should extend. Otherwise there is a danger that the completed adjustment may only accentuate other undulations hitherto unnoticed on the adjacent undisturbed sections of the ground.

Of course, where suitable turf is available on the site it is always preferable, whether or not it is practicable to use it over the entire field, to reserve a sufficient amount of the best quality for turfing any grass-courts, cricket tables,

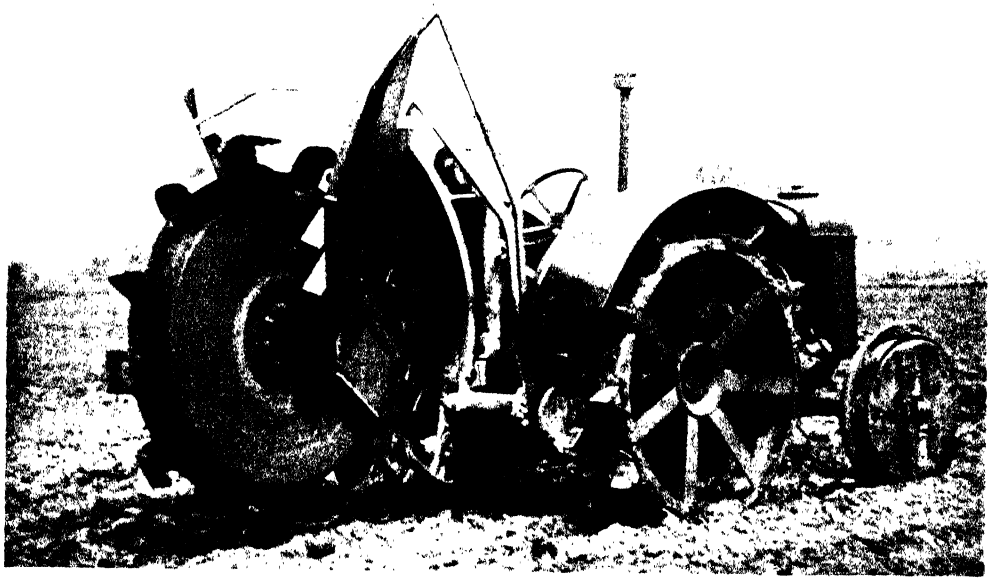


PLATE 16. *The 'Rotcho Trencher' fitted to Fordson Tractor. Suitable for very narrow trenches up to 30 in. in depth in freely workable soils*

PLATE 18. *Mole Plough being drawn through ground*

putting greens, and similar facilities. The formation for these facilities should be prepared in advance so that the turves can be removed from the reserved areas and immediately relaid in their new position, at the most favourable season.

The most suitable dimensions for cutting turves must, of course, depend on the density of the root mat. To specify, as is frequently done, that all turves must be cut 3 feet by 1 foot by 1½ inches thick is simply demanding the impossible in many cases. Some good fibrous turves can be cut quite easily to these dimensions and rolled for convenient handling and transport. On the other hand, some classes of useful turf will not roll and handle if cut to these dimensions without serious risk of breakage and yet can be used quite effectively if cut to smaller sizes. It is best to leave the dimensions to the turfer who will, for his own sake, rapidly determine the most convenient size for handling with the minimum of breakage. Contrary to widely held opinion there is no disadvantage in using torn or broken turves provided the pieces are closely fitted together and firmly bedded. Turves of excessive thickness knit more slowly when relaid.

For the highest degree of accuracy, turves cut in 12-inch squares and boxed to a uniform thickness of from 1¼ to 1½ inches give the best results. For boxing, each turf is placed grass side down in a shallow box of the required depth. The upper edges of the box are finished with sheet steel and the surplus thickness of soil projecting above the edge is pared off by slicing with a knife pressed against the upper edge of the turf box. It follows, of course, that in such work all turves must be lifted ⅛ to ¼ inch thicker than the final thickness to ensure uniformity after boxing. This type of work, however, makes heavy demands on skill and time and is seldom practiced except on the most expensive bowling-greens and similar areas where an accurate surface is of primary importance.

The normal method of turfing large areas is to prepare the soil to the required gradients or contours and firmly roll to consolidate. The turves, cut to the most convenient sizes, are then placed in position with a spade or fork, the surface of the soil being lightly raked in advance of the turfing to offer a better hold and good rooting conditions for the turf. It is usually advisable to dress the soil before turfing with a well-balanced grassland fertilizer at the rate of 2 oz. to the superficial yard and work in by light harrowing before consolidation. Sandy or gravelly soils should also be given a dressing of granulated peat or similar organic manure to improve their water-holding capacity and increase the content of humus. Applications at the rate of 2½ to 4 tons per acre are usual and these must be well incorporated by discing or harrowing before

the final grading for turfing. Heavy clay soils are also considerably improved by applications of peat.

Care must be taken to see that all turves are closely butted at the edges and do not overlap. Any broken turves used must be properly pieced together and any wide joints caused by inaccuracy in shape of the turves must be packed with suitable turf strips. Any marked unevenness due to variation in turf thickness should be corrected as turfing proceeds by drawing out or packing in the soil below the turf as may be required. The entire area should then be lightly rolled in transverse directions to consolidate the turf and smooth the surface. All turfing operations must be suspended when the turf is in a saturated or frost-bound condition.

It will be obvious that where average loamy or clay loam soils are dealt with and the area of levelling or grading is extensive, it will seldom prove economic to endeavour to preserve the turf, as cultivation and seeding can generally be performed mechanically and efficiently at a fraction of the cost, and, as a rule, with much greater surface uniformity. In the case of less cohesive soils, however, such as coarse sands and gravel, or soils containing a large proportion of flints and stones, it is preferable to turf, rather than seed, if suitable turf is available on the site, or close at hand, as seeding on such soils without the incorporation of costly soil amendments is extremely hazardous and much laborious effort will be needed during the long period of establishment.

Subsoil drainage. Where playing fields have to be established on retentive soils, an efficient system of subsoil drainage is very necessary. If waterlogged surface conditions are allowed to arise with any frequency during wet weather, the playing of games is bound to be severely restricted, and, furthermore, a vigorous growth of grass with a high resistance to traffic wear will be difficult to maintain.

Under-drainage, when adequately provided, results in a physical improvement of the soil. Rainfall penetrates more rapidly to the subsoil and there is, consequently, less surface run-off and risk of erosion. Better aeration is secured, resulting in a warmer soil as it requires much less heat to raise the temperature of the air in the interstices of the soil than would be required to warm the water it has displaced. The accumulation of toxic elements is also considerably reduced where air and water can circulate more freely, and bacterial activity, an essential factor in soil fertility, is greatly stimulated. Risk of appreciable surface disturbance through frost-heave or other climatic influences is also diminished.

It is, of course, impossible in a work of this nature to discuss all the basic

principles governing the design of subsoil drainage systems for playing fields. Even if it were possible, there would still remain a number of important but indeterminable factors which can only be dealt with in the light of past experience. Nevertheless, it is important that the movement of water in the soil should be properly understood.

The function of the subsoil drains is to act as an overflow by leading off the surplus free water, as the soil becomes saturated, before it rises to the surface. When rainfall is absorbed by the soil the 'water table' or 'plane of saturation' rises and would eventually reach and overflow the surface unless this rise can be checked at a suitable depth and led away to a convenient point of discharge. This check can be provided most effectively by a series of underground channels or pipes whose main capacity will be determined by the gradient to which they are laid, the area of the land to be drained, the type of pipe or channel used, and the amount of rainfall to be removed in any given time. Having determined the capacity of the main drains along these lines, an adequate number of collector or feeder drains are dispersed throughout the area to intercept and direct the flow to the mains. The depth and spacing of these secondary feeder drains will be determined by the texture and structure of the soil which they traverse.

It will be understood that the movement of the surplus soil water under gravitational influence will be retarded to a greater or lesser degree by the nature of the soil and that the farther the mass of water is from the drain, the greater will be the hydrostatic pressure or 'head' which must be built up to overcome the frictional resistance of the soil to its movement towards the drain. Consequently, the water table will be curved upwards from the invert level of the pipes with the highest point midway between the drains for soils of uniform texture and tilth. This degree of curvature will be greater naturally for the more dense and finely textured soils than for the more permeable coarsely grained soils. This is illustrated in the diagram Fig. 45 from which it will be obvious that if the spacing of the drains is too wide in relation to the depth, the crown of the saturation curve may reach the surface causing wet spots between the drains.

Land drainage has been the subject of much intensive technical research, and mathematical formulae have been devised for the design of the pipe systems. These formulae, based on investigation by various authorities, are by no means consistent in their results as may be expected where a problem embraces so many indefinite factors whose influence on the solution can only be decided by certain theoretical assumptions—based on somewhat restricted experimental observations—which may or may not be realized in practice.

Without discussing in detail the various theories and deductions, the following suggestions are offered as following closely the general practice in relation to the drainage of sports grounds and should prove satisfactory under normal conditions.

It is, of course, most important to determine at the outset whether the water-logged conditions of any particular site can be overcome by a purely local system of land drains. There are many low-lying fields adjoining rivers or streams subject to occasional flooding, which have to be accepted with their climatic limitations on the periods of play. Yet cases have been known where

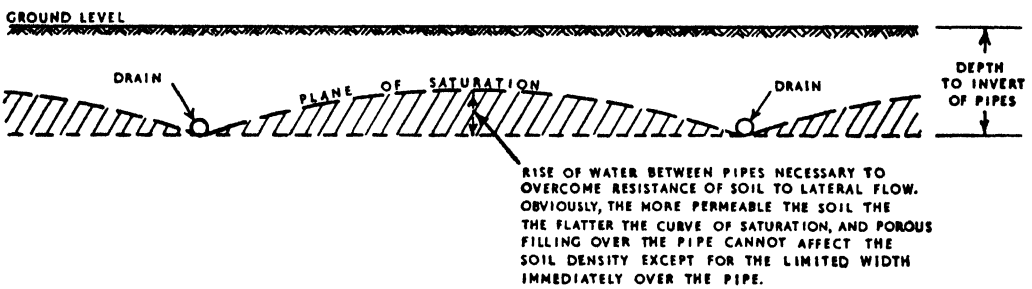


FIG. 45

fields of this nature have been piped at appreciable cost with an outfall provided into a stream which frequently overflowed the ground in winter. In such circumstances the drains are quite incapable of functioning just when they are most required and their installation tends to aggravate, rather than improve the conditions.

The following table shows at a glance the area in acres which the usual size of main drain can conveniently cope with at various gradients. The figures are based on the removal of $\frac{1}{4}$-inch of rainfall in twenty-four hours. It would, of course, be quite uneconomic to design installations to cope with the maximum rate of rainfall, but as the heaviest showers are generally of comparatively short duration, the daily average is not as a rule seriously affected. It is suggested, however, that the acreages shown against various sizes of pipes are suitable for those districts where the average annual rainfall does not exceed 40 inches.

The acreage served by the mains should be reduced by the percentages shown within the limits of annual rainfall as stated:

Annual rainfall 40 to 60 inches reduce acreage by 25 per cent.
" " 60 to 80 " " $33\frac{1}{3}$ per cent.
" " over 80 " " 50 per cent.

DIAMETER OF PIPE	ACRES DRAINED AT GRADIENTS AS INDICATED				
	1 IN 500	1 IN 300	1 IN 200	1 IN 100	1 IN 50
4 inches	7·25	9·33	11·50	16·50	23·00
6 „	23·00	29·00	36·00	50·00	72·00
9 „	70·00	90·00	110·00	156·00	220·00

No subsoil drain of major importance should be less than 4 inches diameter and it is seldom necessary to exceed 9 inches diameter on any average playing field except in those instances where an existing watercourse has to be piped, or where the surface run off from impervious or paved areas has to be disposed of, in which case the size of pipe will be proportioned after properly gauging the additional flow from these sources.

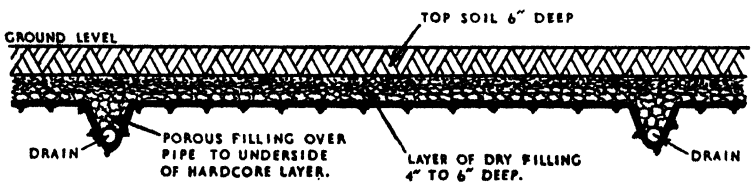
All principal drains should be sited, wherever practicable, clear of any playing facilities so that in the event of opening up for examination or repair there will be little or no interruption of play. It is very desirable to provide inspection silt pits at every change of direction or change of gradient, at any point where the capacity of the pipe is increased, and at each junction of main and submain. These pits are not, as a general rule, installed on sports-ground drainage systems, but there is no doubt that where the cost of their provision can be faced, they afford a convenient means of examining from time to time the efficiency of various sections of the drainage system. In any case an inspection chamber should always be provided just before the main outfall.

Inspection or silt pits may be of concrete or brickwork on concrete foundations, and the floor of the pit should be 1 foot below the invert level of the pipes. Internal dimensions would, of course, depend on the depth of the drain, but should not be less than 2 ft. 6 in. by 2 ft. 6 in. Pits should be provided with precast reinforced concrete covers to finish approximately half an inch below level of the surrounding turf so as not to interfere with mowing operations. Where pits cannot be sited in the margins or surrounds clear of the actual playing areas, they should be finished with their covers 9 inches below the surface, soiled and turfed over, and their positions carefully measured and recorded.

All main and submain drain trenches should be filled to within 9 inches of the surface with good, clean boiler clinker, coarse gravel, or small, broken hardcore, after pipes have been laid, and the upper part of the trench finished with the best of the topsoil from the excavations. Trenches should be as narrow as possible consistent with convenience in laying the pipes and economy in cutting the tracks. Porous filling to main drains is very advantageous on

grounds where under constant rolling, mowing, and other maintenance traffic the surface and subsoil becomes tightly compacted. In such circumstances a good structural condition extending well into the subsoil may be restored by drawing a mole plough or subsoiler throughout the area at close centres and commencing each run of the mole or subsoiler from the porous filling over the main drains.

Branch or feeder drains need not be porous filled as this will in no way increase the flow of water through the subsoil except on the line immediately above the drain. Between the drains, as has already been indicated, the free



POROUS FILLING TO ALL DRAINS WILL RAPIDLY DISPOSE OF RAINFALL IF A PERMEABLE LAYER IS INTERPOSED BELOW TOPSOIL TO PERMIT A MORE EASY PASSAGE OF WATER TO THE DRAINS. THIS IS USUALLY TOO COSTLY FOR GENERAL PRACTICE.

FIG. 46

water can only be forced towards the pipe by the hydrostatic pressure or 'head' developed and will enter the pipe from the bottom of the trench. Consequently, porous filling in such cases can serve no more useful purpose than as a filter medium, a function which could be more effectively and economically performed by a thin compressed layer of straw around the pipe before backfilling the soil previously removed. Of course, where it is necessary on important pitches to provide for rapid percolation and disposal of rainfall before it has time to saturate the subsoil, it is usual to interpose a layer of clean coarse permeable material such as gravel or fine clinker to a depth of 3 to 4 inches between the top-soil and the subsoil, to promote an easier passage for the rainfall to the drains. In such cases, the branch drains should be porous filled to the underside of the gravel or clinker layer as shown in Fig. 46.

Land drains will function effectively at very slight gradients, but it follows that the flatter the gradient, the more serious will be the defects arising from poor quality pipes, or inaccuracy in laying. Most sports grounds, however, where major levelling has been carried out are completed to gradients of from 1 in 80 to 1 in 60 except in very hilly districts where, on grounds of economy, much steeper gradients have to be accepted. It is generally possible therefore

to lay the pipes in such cases at a uniform depth below the surface which greatly facilitates the use of mechanical trenchers for this purpose where the quantities are sufficiently large to justify their use. On more level sites, gradients of less than 1 in 300 for drains should be avoided unless the highest degree of accuracy in grade and alignment can be assured.

Main drains should not be less than from 2 feet to 2 ft. 6 in. deep with branch drains from 18 to 24 inches deep. The shallower depths are generally recommended for clay soils with spacings of branch drains from 10 to 15 feet apart. The greater depths are advisable for more permeable loamy soils with spacings of branch drains from 20 to 40 feet apart. Branch drains should be laid as far as possible in parallel rows diagonally to the main slope of the field and connect to the main drain in an oblique or herringbone fashion. The last yard of each branch drain should drop down to discharge into the bottom of the trench of the main drain. With porous concrete pipes spacing between rows may be increased by 50 to 100 per cent. but this wider spacing demands deeper drains.

Outfall to streams or ditches must be adequately protected by a suitable concrete spillway against collapse of the surrounding earth by scouring or erosion of the stream bank. The end of the pipe should be protected against the entry of vermin by a suitable grating and where the outfall is submerged at any time a flap valve should be fitted to prevent backflow and the consequent risk of rapid accumulation of silt in the pipes.

No branch drain should be less than 3 inches in diameter. Pipes of smaller bore silt up more rapidly. Excessive lengths on branch drains should be avoided. They should never exceed 100 yards in length. It is better to provide extra mains than to extend branches unduly.

Some typical drainage arrangements are shown in Figs. 47 to 50.

Where a field adjoins, on one or more boundaries, higher ground sloping towards the playing area, or where excavations have been necessary to reduce surface gradients, it is generally advisable to provide a catch drain at the foot of the slope or cutting to trap and divert any surface run-off from the higher ground. Such drains are more effective if porous filled to the surface. Similarly, where the level of the field has been raised above that of the surrounding properties, the effect of surface run-off and the possibility of flooding on adjoining lands must be considered, and adequate precautions taken on similar lines.

It must be stressed that the effectiveness of subsoil drainage of sports fields on dense soils will be less appreciable unless some measures are adopted to ensure and maintain a fairly permeable condition of the surface soil.

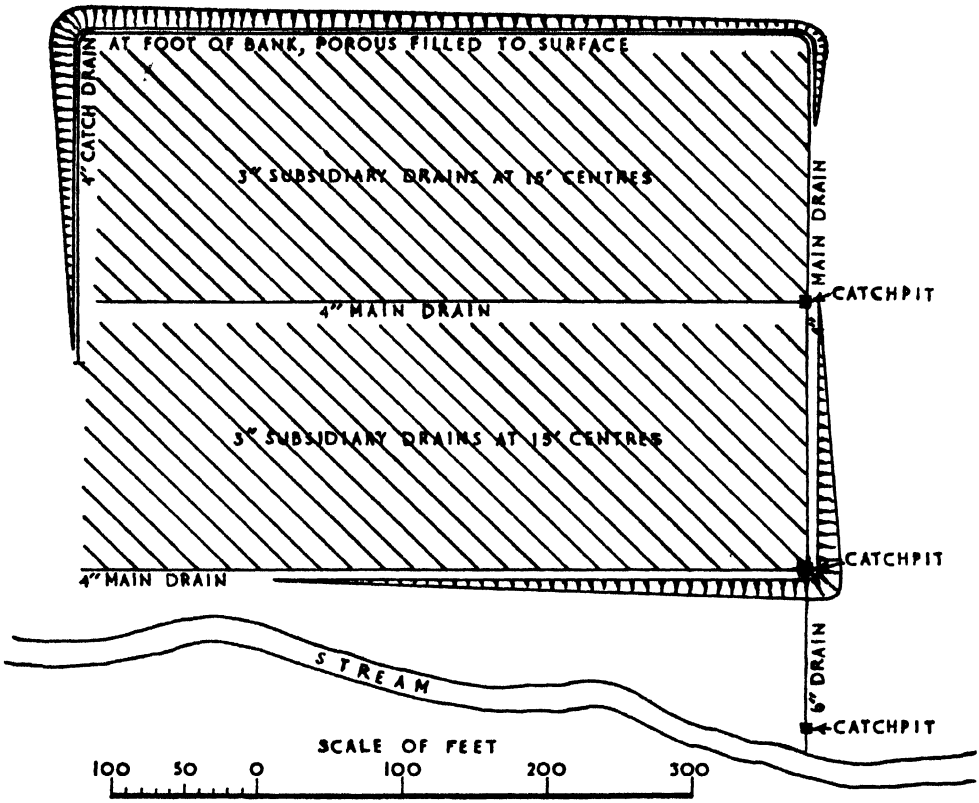


FIG. 47. TYPICAL EXAMPLE OF SPORTS FIELD DRAINAGE

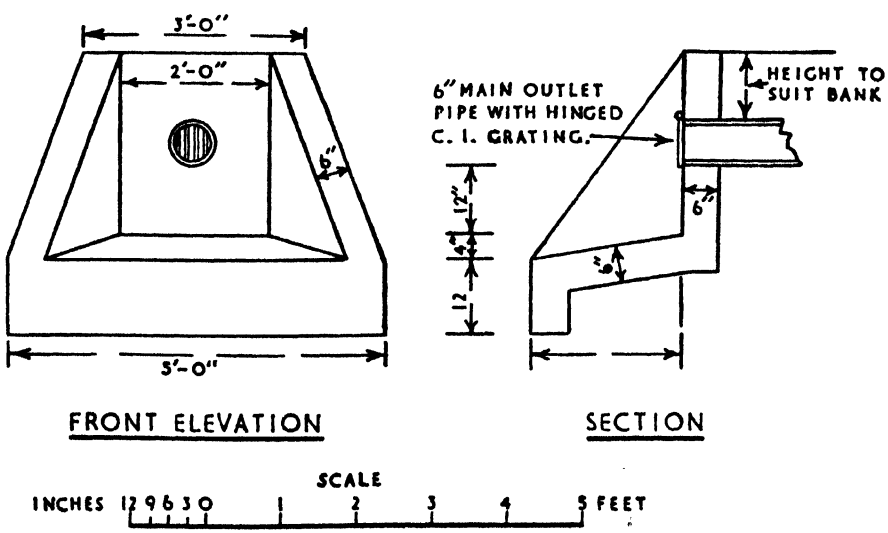


FIG. 48. TYPICAL CONCRETE OUTLET TO STREAM OR DITCH

It is of little use making provision for disposing of subsoil water if the ground surface is allowed to reach a state in which the percolation of moisture becomes impossible. Cases have occurred where the surface has remained in a wet puddled condition for days after rain has ceased, although on examination the subsoil was found to be well drained and dry. The cause was excessive play on highly plastic soils when in a saturated condition, followed by heavy rolling to smooth the surface for further play. Under this treatment the colloidal material is forced by pressure to the surface where it is compressed to form an impervious skin which smothers the growth of grass and prevents any circula-

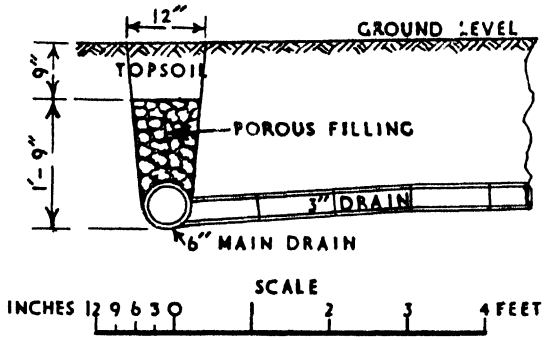


FIG. 49. DETAILS OF MAIN DRAIN WITH POROUS FILLING AND LATERAL DRAIN CONNEXION

tion of air or moisture. Soils of this nature require the incorporation of textural improvers such as gritty sand, fine clinker, or granulated peat in suitable proportions during the final preparation or cultivation of the surface to counteract the excessive plasticity if the full benefits of subsoil drainage are to be attained.

Pipes for subsoil drainage may be of burnt clay, or porous and non-porous concrete. Whatever type is favoured, they should be of a quality equal to that laid down in the appropriate specifications of the British Standards Institution (B.S. 1194/1944 Concrete Porous Pipes for Under drainage, and B.S. 1196/1944 Clayware Field Drain Pipes). Pipes should be carefully laid to proper alinement with closely butted joints. Protection against grit or soil entering the joints or clogging the pores of porous pipes during backfilling may be prevented by covering and surrounding the pipes with a thin layer of straw or by laying a strip of waterproof paper or turf over the upper half of the pipes before backfilling. In backfilling the trenches care must be taken in tamping not to damage the pipes or disturb their alignment. Thorough consolidation of the trenches after filling is essential to eliminate risk of subsidence.

Mole draining. Mole draining by itself is not generally of sufficient permanent value to recommend for the drainage of sports fields. It is, however, comparatively inexpensive to carry out and may be used with advantage to augment

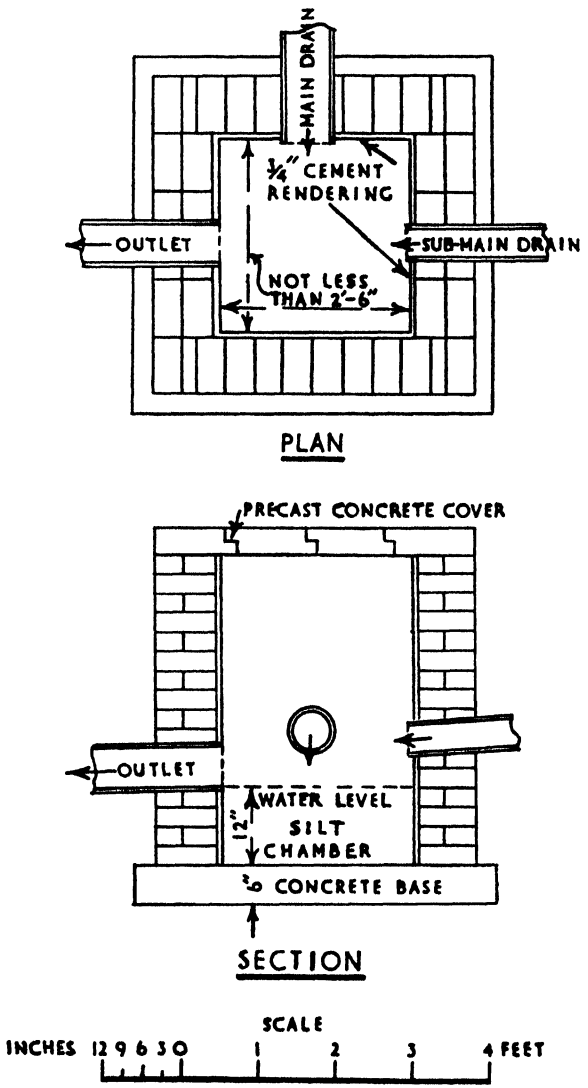


FIG. 50. DETAILS OF CATCHPIT

pipe drainage systems from time to time on soils which become panned or tightly compacted by traffic or maintenance operations. Even where the channels formed by the moles are not sufficiently stable, the subsoiling effect produced by the passage of the implement is usually of immense value in

restoring a more open soil structure through which water may move more freely. Moles should be drawn diagonally against the general slope of the ground. If drawn from an open trench or ditch, the discharge ends can be effectively strengthened against collapse by inserting a tile pipe of appropriate size.

Drainage works have been greatly facilitated by the wide use of trench-cutting machines. Some of the types available are shown in the following illustrations:

Plate 12. A Barber-Greene Vertical Boom Ditcher. These machines are available in sizes to suit most normal trenching widths, but the most popular size for land drainage work cuts a trench from 8 to 11 inches in width up to 5 feet deep. Through the 4-speed main transmission and 8-speed digging transmission there are 24 digging speeds available ranging from 1·0 to 8·8 feet per minute so that it should be possible to find an efficient rate of working for almost any soil conditions. It will be seen from the photograph how the spoil is thrown well clear to one side of the trench.

Plate 13. A Priestman Cub Excavator fitted with special 'Teredo' trenching scoop for land tile drains. Note from the inset the grooved bottom made by the scoop for housing the drain tile. Plate 14 shows another type of back acting excavator on trenching work. These machines are slower in action than the bucket trenchers under normal conditions and they are more difficult to control in alinement and working widths. Where, however, they are already in the neighbourhood on other excavator work, the trenching attachments are available, and the trenching work is not sufficiently extensive to justify the transport of a special machine their employment will be found expedient.

Plate 15. A 'Cleveland' Model 75 trencher, a popular model of bucket wheel trencher for land drainage work. Cuts trenches from 9 to 12 inches wide up to 3 ft. 6 in. deep. Sixty speeds available in either direction for travelling and for digging ranging from $\frac{1}{2}$-foot per minute to 2 miles per hour. A larger make of this machine is available for wider and deeper trenches.

Plate 16 shows a smaller type of trenching machine, the Roteho trencher, which is fitted to a Standard Fordson tractor and cuts a trench approximately 8 inches wide up to 30 inches in depth. The machine operates very well in soils when not too sticky or too loose and free of boulders or other obstructions. It has the great advantage of being more easily transported than the heavier machines and can therefore be profitably employed in many instances where the cost of bringing a larger machine to the site might be prohibitive. It is only

suited, however, for very narrow trenches of shallow depth and in favourable circumstances is capable of cutting up to 10 chains per hour.

There are many other types of drain-cutting machines including those of the trench-plough type which shear out a trench of the required width and depth in one or more slices according to the type of machine and the motive power available. Under certain soil conditions we have seen effective work accomplished by implements of this type, but the range of optimum conditions for their efficient and economic employment is rather narrow.

Plates 17 and 18 illustrate typical mole-draining operations. Plate 16 shows the mole about to enter the ground and Plate 17 gives a view of the mole being pulled through the ground. The line of cleavage formed by the knife is closed by subsequent rolling, but it will be appreciated that the thrust caused by the passage of the mole must loosen the soil structure for some distance around the mole and leave it in a more open and permeable condition.

CULTIVATION AND SEEDING

Major levelling or grading completed, drainage requirements fully met, and top-soil replaced to an even depth, the ground is now ready for final cultivation and seeding.

Lime dressing. There are few occasions where a dressing of agricultural ground lime is not beneficial. Apart from its sweetening of the soil, it increases fertility and has a marked effect on the physical condition as it tends to bind the more open and loose soils and promotes flocculation of more tenacious soils. Usual rates of application are from 1 to 2 tons per acre. Every care should be taken to ensure a uniform spreading and thorough incorporation with the top-soil by suitable operations of the cultivator, disk harrows, or heavy harrows.

Fertilizing. A good well-balanced fertilizer applied at rates of from 3 to 5 cwt. per acre is very desirable before seeding. There are many proprietary ready-mixed grass-land fertilizers to choose from which are comparatively inexpensive and more easy and safe to apply than home-made compounds from crude chemical ingredients which may do more harm than good unless the man preparing them has a thorough knowledge and experience of the materials he is using, and can ensure the conditions for accurate proportioning and mixing.

Organic dressings, such as granulated peat, are also useful, especially if incorporated in the surface of the areas which will be subject to the most severe foot traffic. Rates of application from 30 to 60 cwt. per acre.

Seeding. After fertilizing the surface should be brought to a smooth, even contour free from any pronounced mounds or hollows by suitable operations of harrows, road-drags, or rigid graders, followed by a light roll to consolidate.

The choice of a suitable mixture of grass seed for important and extensive areas should be given the most careful consideration, and it is well worth while to consult an experienced agrostologist whose advice may save much time and expense. For an agreed fee, experts of the St. Ives Research Station, Board of Greenkeeping Research, Bingley, Yorkshire, will examine your soil samples and make recommendations in this respect.

For smaller schemes, where it is preferred to proceed on general lines, the following mixture may be recommended for ordinary outfield purposes. It has given satisfactory results under varied soil conditions:

60 per cent. Short-seeded perennial rye grass.
20 per cent. Chewings Fescue.
10 per cent. Poa pratensis.
10 per cent. Agrostis tenuis.

For areas requiring a finer mixture, such as cricket tables and tennis courts, the following mixture has proved satisfactory in normal circumstances:

40 per cent. Chewings Fescue.
40 per cent. Crested Dogstail.
10 per cent. Poa pratensis.
10 per cent. Agrostis tenuis.

For bowling greens and the highest grade lawns:

80 per cent. Chewings Fescue.
20 per cent. Agrostis tenuis.

Rates of Seeding. There is a considerable diversity of opinion as to the desirable rates of seeding for sports turf. Many farmers asked to sow down small village fields think a seeding rate of 112 lb. per acre grossly extravagant, whereas the common practice on sports ground or landscape construction is to seed at rates of 2 cwt. and over per acre. The farmer, of course, usually sows for forage purposes with much coarser grasses and expects the maximum development from each individual plant. While good results have been achieved on sports fields with sowing at from 100 to 112 lb. per acre, and even less, it generally calls for much greater effort to develop a close dense turf. Normally, a seeding rate of less than 2 cwt. per acre on general playing fields is not to be recommended. The more closely the plants are crowded together, the finer will be the texture of the sward and less trouble will be experienced

with tufted growths. There will be, furthermore, less bare spots where weeds may germinate freely.

Smaller facilities such as cricket tables, tennis courts, bowling greens, and putting greens are usually sown at rates of from 1½ to 2 oz. per superficial yard.

Seeds should be sown on a still day. Even distribution under any appreciable breeze is extremely difficult. The seed to be sown should be divided into two parts and applied in two operations, by broadcasting mechanically or by hand according to the extent of the area to be sown. The second sowing should be carried out in a transverse direction to the first. Seeds should then be lightly raked or harrowed in to give cover and the area lightly rolled to consolidate.

All traffic should be avoided on newly sown areas until the growth has been fairly established and even then should only be allowed when the soil is in a fairly dry state. When the grass is from 3 to 4 inches high it should be cut, the mower blades being set fairly high for the first cutting. Grass cuttings where the growth is very heavy should always be removed from the surface. When, however, regular mowing has commenced and the cuttings are comparatively light and not likely to interfere with play, they could with advantage be allowed to remain, especially during dry periods when they might be useful in retarding loss of soil moisture by evaporation.

The first cutting should be followed by a light roll. Where, however, the cutting is performed by a self-propelled motor mower with trailer seat, the weight is normally sufficient to ensure adequate contact between grass roots and soil without additional rolling. Rolling and mowing newly sown areas should be suspended when the soil is appreciably moist, otherwise, especially on retentive soils, the surface may rapidly become 'capped' or 'hidebound'.

Regular cutting and rolling under the right conditions, gradually lowering the blades of the mower at each cutting till the desired limit is reached, will rapidly thicken the growth, improve the texture of the sward, and greatly assist in holding weeds in check.

The advantages of heavy powerful tractors in speeding up the work on fields of large acreage may be appreciated from the photograph, Plate 19, showing a 'Cletrac' crawler tractor operating a multi-power plough. With ample power these heavy tractors are capable of operating much larger implements and consequently increasing the width of cover in all cultural operations without loss of efficiency. In contrast, Plate 20 shows the rotary hoe, one of the smaller types of cultivating machines, normally obtainable in two sizes, with cutting widths of 20 or 36 inches and capable of tilling up to 8 inches in depth. There are three forward speeds ranging from ⅝ to 1½ miles per hour

approximately. There are quite a number of other two-wheeled self-propelled cultivators for operation at walking speeds. Some are equipped with tool bars for fitting ploughshares, cultivator points, disks, harrows, and other narrow width implements. These are quite handy little machines for cultivation work on small fields up to 3 or 4 acres in extent where no levelling or grading is required and the going is not too heavy.

Normally, however, most sports fields of average size are efficiently constructed with ordinary agricultural tractors (Fordsons or similar types) operating the usual range of cultural implements, readily at hand in most country districts, augmented where necessary by any special equipment required for levelling, grading, or draining according to the extent of such works.

Rotary cultivators of varying types can also be obtained for operation by farm tractors. This method of cultivation produces a very fine tilth much more rapidly than by ploughing and harrowing, but in the writer's opinion when used on heavy soils the pulverizing effect has a tendency to promote tighter packing of the surface should heavy rains follow the cultivations. They are excellent, however, for clearing the surface of heather and similar growths and for cultivating lighter and more open soils.

Purchasing grass seeds. On large contracts requiring appreciable quantities of grass seeds it is always best to obtain supplies of each species comprising the mixture in separate containers along with a copy of the Government certificate and date of test for purity and germination. Owing to the difference in weights of the various species included in any mixture the proportions cannot be uniformly maintained throughout the consignment under the disturbances which must take place in transit and during handling in store. Greater consistency in the mixture sown is likely to be obtained when mixed in proper proportions just before seeding.

Where it is desired to check the purity and germination percentages, samples should be forwarded to The Chief Officer, Official Seed Testing Station, Huntingdon Road, Cambridge, who will examine and provide an analysis for a nominal fee.

For comparing tenders of varying purity and germination the following calculations will give equivalent price per cwt. of 100 per cent. pure germinating seed.

$$\frac{\text{Per cent. germination} \times \text{per cent. purity}}{100} = \text{Real Value.}$$

$$\frac{\text{Price quoted per cwt.} \times 100}{\text{Real value}} = \text{Price per cwt. of 100 per cent. pure germinating seed.}$$

LEVELLING BY CONTROLLED TIPPING

There are many hilly and mountainous districts where no reasonably level land is available for adaptation to sports purposes, and where levelling by cut and fill may be impracticable in view of the enormous quantities of excavated materials to be handled and the fact that the major part of the excavations would in many cases have to be carried out in solid rock which would place the cost well beyond the capacity of any local authority. Large urban authorities, however, are frequently faced with the problem of disposing of large quantities of household refuse, street sweepings, market and other litter accumulated daily by the community and this can be economically achieved by reclaiming derelict, uneven and unsightly areas through levelling off for use as playing fields or open spaces by the method of controlled tipping. In this way unsuitable plots of land have been in time converted to useful facilities for physical recreation.

The City of Bradford has given a splendid lead in this direction and many acres of playing space for public and private use within the city boundaries have been developed in this manner at a fraction of the cost that would otherwise have been necessary. Controlled tipping as practised in Bradford is hygienic, and creates no nuisance, as the refuse eventually becomes inocuous. The method is economical both in capital expenditure and plant maintenance, as it has been found that once the advantages of controlled tipping are fully appreciated, many sites are offered free of charge so that they might be reclaimed for public use. One site inspected by the writer is the Bradford Grammar School playing fields, where tipping has been carried on for eighteen years, and although many valuable games pitches have been brought into use, further tipping facilities still exist for several more years.

Of course, various local factors have to be taken into account in determining the suitability or otherwise of a site for tipping. Access, capacity, surface configuration and the layout of the site all have a bearing on the cost. Then again the presence of water may necessitate a heavy expenditure on culverting or draining which may make the cost prohibitive. Crude refuse should not be tipped in water as this may result in the germination of obnoxious gases with consequent nuisance. The proximity of dwellings must also have a great influence on the operation of the tip, and the availability of suitable covering material on the site or nearby will have a bearing on ultimate costs. It is always an advantage in operating such tips if connexions to public services—water, gas, or electricity—can be effected conveniently.

PLATE 19. *Crawler Tractor and Multi-Furrow Plough in action. High-powered Tractors and implements speed up operations*

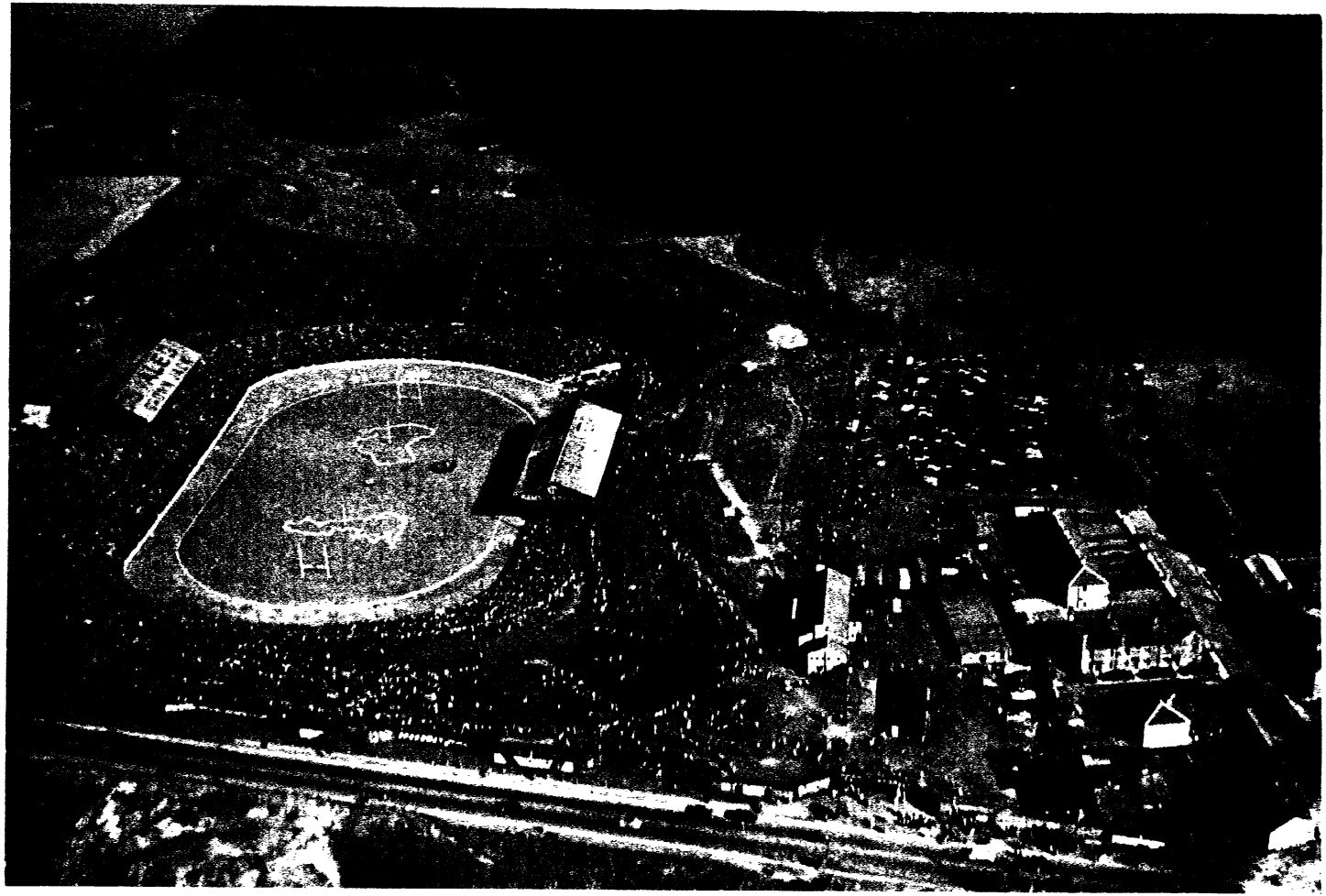


PLATE 21. *Odsall Stadium, Bradford, on the occasion of an England v. Australia Rugby League Test Match. Stadium formed by filling a natural valley by controlled tipping*

In planning the work the approaches to the ultimate tipping points should be maintained to gradients which can be traversed easily and safely by mechanical transport vehicles, and the tipping points should not be more than 7 feet above the bottom of the area being filled. The time taken to complete the tipping of any site will, of course, depend on the capacity of the area to be filled and the output of refuse from the locality feeding the tip.

Where good turf and vegetable soil exists over the area it is advisable to strip this to a depth of at least 6 inches and lay aside for the final covering to form a seed bed. Care must be taken in selecting sites for these spoil heaps to avoid hampering operations on the tip, or making it necessary for further movement of the top-soil before the final respreading.

Before commencing tipping the site should be carefully surveyed and a plan and cross sections of the finished scheme prepared. The tipmen must then be briefed as to the manner of procedure, the ground being marked out for the first layer—(where the depth of the fill exceeds 7 feet)—in strips 45 feet wide with profiles set for filling 7 feet deep, the banks being sloped to 40 degrees. This width of tipping allows ample space for two or three vehicles to manœuvre and tip along the face at the same time, thus avoiding the danger of one load being tipped rapidly down the face on top of the previous load before the salvage men working on the face have had time to pick out the paper and other saleable material. The depth of 7 feet allows for one foot sinkage during consolidation.

During the progress of controlled tipping a thorough and effective seal must be maintained to exclude the atmosphere and retain the heat generated by decomposition. Temperature tests indicate that a rise of temperature up to 160° F. at a depth of 6 feet may be reached in three weeks time, after which a gradual fall should be experienced until a return to normal temperatures in about twelve months. Temperatures over 180° F. would indicate possible danger of fire as a result of spontaneous combustion. Fires are a source of danger on a tip and may also be caused in other ways. Hot ashes from dustbins are a common cause and men should be warned to look out for such dangers. The principal cause of tip fires, however, is generally considered to arise from tipping to excessive depths inducing spontaneous combustion. Once a fire has started it should be dug out if at all possible.

In tipping, no pockets should be allowed to form. Unsalvageable materials such as beds, mattresses, &c., must be laid out flat at the bottom of the tip, all bundles being opened and spread out. Glass and earthenware should be broken up at the bottom of the tip. Broken glass on the tip surface is not only

a danger to tyres but may focus the heat of the sun and create further risks. Any large containers, tins, &c., should be filled with refuse or other material at the tip bottom or flattened out before being buried. Fish refuse and offal must be tipped at least 3 feet below the surface.

Each days' tippings must be thoroughly sealed by a covering of ashes, clinkers, street sweepings, and screened dust with gully refuse to bind the tip banks and make them firm. In this way the tipping process is effected in a clean and orderly manner without nuisance. Consolidation of the tip is effected by the constant movement of vehicles over the surface, and the solidity of the tip prevents any vermin lodging therein.

Screens of netting are erected on the windward side of the tips to prevent papers being blown off the tip on to adjoining lands. This is very important where dwelling-houses are near to the tip.

An up-to-date tip should be provided with dining, washing, clothes drying, storage facilities, and conveniences on the site. Cabins constructed of timber erected on concrete foundations are appropriate for this purpose. Effective temporary lighting of the tip is also useful during winter months.

All tipmen start and finish half an hour later than the dustmen to allow time to cover the tip properly before leaving.

The photograph, Plate 21, shows the Odsal Stadium which was constructed after filling a natural valley with thousands of cubic yards of household refuse. Before tipping commenced a culvert had to be constructed to contain the stream flowing through the valley. A large car park has also been formed and extensive terracing accommodation for spectators. This illustrates how excellent playing facilities may be established on a most unfavourable site by using mainly discarded materials whose disposal might otherwise be a dead loss to the community. Such projects are surely well worth the time and effort.

The author is extremely indebted to Mr. J. W. Call, M.I.P.C., Director of Public Cleansing, City of Bradford, for allowing him to inspect many schemes completed by his department, and for providing notes and photographs from which this brief outline has been prepared.

TURF PRODUCTION ON STONY SOILS

In many districts considerable difficulty will be experienced in endeavouring to establish a good sports turf on stony soils. The presence of large stones on the surface not only hampers efficient maintenance by frequent damage to implements, but interferes with play and may cause serious injury to players.

The simplest way of dealing with the problem is to import sufficient stone-free loamy soil to cover the graded surface to a depth of not less than $4\frac{1}{2}$ inches to provide a reasonable seed bed. In many cases, however, this is quite impracticable for economic reasons as these stony soils may extend over many square miles. It would therefore mean going very long distances to obtain any better soil, and the resulting transport charges would make the cost prohibitive. Riddling the soil to remove the stones is also uneconomic over the larger areas, although it is very advisable for the more restricted and special areas such as tennis courts, bowling greens, putting greens, cricket tables, and similar features where the turf is to be established from seed.

If good turf can be procured at a reasonable cost, this will provide a quicker and more satisfactory cover despite the heavier cost over seeding. For covering stony soils, however, the turf should be lifted fairly thick—approximately $1\frac{3}{4}$ to 2 inches—despite the longer time required for knitting together at the joints by increasing the thickness.

Where, however, for economic reasons the best use has to be made of the materials found on the site, a suitable turf can be established from seed with patience and perseverance. The soil has to be broken up and cultivated in the usual manner and graded. After the final cultivations the larger stones (all over 3 inches in diameter) brought to the surface during the various operations should be collected and removed from the site.

Heavy applications of chemical fertilizers and peat are advisable on soils of this nature and these should be well incorporated in the surface during the final cultivations. The area should then be well rolled in transverse directions and seeded as before described.

Should heavy rain follow the cultivations and seeding, much of the effect of the previous stone picking may be lost as the soil may be washed below the level of the stones previously covered. Nevertheless, the seeds should be allowed to germinate before any further clearing is attempted, and when the grass is about 4 inches high, it should be topped by a reaper or mower with the blades set high. Any large stones which have worked to the surface since the seeding should be removed in advance of the mowing.

Frequent rolling when the soil is in a fairly moist condition will help to force the finer particles of soil to the surface and press in the smaller stones and in time ensure a thin cover of soil for the establishment of a uniform growth over the surface. There is little danger of packing too tightly stony or gravelly soils when wet, although the practice is not one to be generally recommended under more normal soil conditions.

Gradual lowering of the blades of the mower as before described with each cut, until the desired length is obtained is, of course, essential, and when the cuttings are light enough not to smother the growth they may be left to enrich the organic content of the soil and increase the depth of cover. Careful removal of any large stones which may work out during the initial stages of establishment and are likely to damage implements or players should be attended to as found necessary. This necessity, should, however, diminish in time if regular rolling is persevered with.

TURF CULTURE AND REINFORCEMENT WITH BITUMINOUS PEAT OR BITUMINOUS SAND CARPETS

These processes were introduced by Mr. T. F. N. Alexander, of Messrs. Alexander Products, Ltd., Bristol, as a method of stabilizing grass surfaces on airfields during the war. The author was closely associated with those experiments on numerous aerodromes throughout the country but, while some very remarkable results were achieved, he was not satisfied that by themselves these applications would ensure effective surface stability for any appreciable length of time on wet sites. It appeared to him that the effective control of water in the soil was a basic factor in securing surface stability.

There was no doubt, however, that the application of these surface dressings did stimulate growth to a remarkable degree and, by checking the rise of colloidal material from below and its consequent distribution over the herbage, tended to retard the development of soft muddy conditions on the surface for a more or less limited period. The dressings were made both to established turf and to newly sown areas with equal success.

There are two main methods which can be varied to a certain extent as circumstances may demand. The first is a pre-mixed preparation of special peat and bitumen applied in a comparatively dry state over the newly sown or turfed areas to a loose depth of from $\frac{3}{8}$ to $\frac{1}{2}$ inch. The second method is to dress the seeded or turfed area with special peat or sand, spray with bitumen emulsion, and cover with sharp sand, the total depth of this covering to be approximately half an inch. No rolling or traffic should take place on the treated areas before the growth has broken through and become well established, otherwise the grasses may be smothered.

Where the subsoil is effectively drained and the surface gradients are sufficient to throw off the rainfall and prevent ponding, fairly firm surface conditions for normal traffic may be secured by these methods.

The writer believes there is a great future for these surface treatments in the

solution of certain problems of sports-field construction if the cost can be kept at an economic level. Not only should it be useful for producing a more vigorous and hard-wearing turf for tennis courts, bowling greens, cricket tables, and similar features, but it should be excellent for stimulating the development of turf from seed on loose stony or gravel by soils to provide a more rapid cover. Such soils, of course, would have to be improved by the incorporation of organic manures and chemical fertilizers to enhance their water-holding capacity and provide adequate reserves of plant food for nourishing the seed.

The great trouble with loosely bound soils lacking in humus is that when bare of herbage they are rapidly eroded by high winds or heavy rains. Seeding under such conditions becomes a hazardous business, as heavy rains may wash the finer material and seed well below the surface, or high winds distribute them over distant areas. These bituminous peat or sand coverings would therefore fix and protect the seed against dislodgement by wind or rain or the ravages of birds, and ensure a maximum germination. The writer has been particularly impressed with the rapid establishment of seeded areas treated by these processes. Not only was the growth more vigorous than on other areas seeded at the same time without protective covering, but dressed areas were definitely freer from weeds than the untreated areas. The methods and rates of application demands a considerable amount of experience and skill to ensure the best results.

These surface treatments appear to act somewhat in the manner of a mulch and conserve the capillary moisture through checking loss by evaporation. They also have a marked influence in raising soil temperatures and these no doubt are important factors in the improved growth which is so noticeable.

Messrs. Suttons of Reading, in conjunction with Mr. T. F. N. Alexander, have carried out some interesting tests to ascertain the effects of the treatment on various mixtures of grasses sown in soils of varying texture. The results of this investigation are set out in a brochure (price 3*s.* 6*d.*) entitled *A Study of the Growth of Grass in Surface Stabilised Soil* by Martin A. F. Sutton, F.L.S., and readers wishing further information should obtain a copy.

CRICKET TABLES

The cricket table on which match wickets are to be prepared from time to time throughout the season should be excavated to the required depth to allow a layer of good clay loam to be provided of at least 8 inches consolidated thickness where the subsoil is of a sandy, gravelly, or permeable nature. Where the

subsoil is of a more tenacious character, it is advisable to provide a foundation layer of at least 4 inches consolidated of broken chalk or hardcore, below the layer of clay loam which in this case should not be less than 6 inches consolidated. Wet subsoils should also be drained by means of a 3-inch diameter porous filled land-drain laid round four sides of the table to trap and divert any water before it has time to seep in from the outfield and affect the base of the table. The porous filling over the pipes should extend up to the base of the hardcore foundation.

The soil layer should then be raked or screeded to proper levels to marry in easily with the surrounding outfield, and lightly consolidated. A dressing of approved grassland fertilizer at the rate of 2 oz. to the superficial yard could then be applied with advantage, and this should be well raked or forked into the surface, which must be again relevelled, lightly consolidated, and seeded or turfed in the manner as before described.

The best turf for cricket wickets is that obtained from a strong-growing pasture on a heavy clay loam. Turf of a spongy or peaty character is quite unsuitable for cricket wickets, and if no better turf is available it is much better to seed the table.

If the soil is of a light nature the upper 6 inches should be improved by forking in 20 to 30 per cent. of clay or marl and bringing to as uniform a consistency as possible before fertilizing and seeding, or turfing, as may be most expedient.

Areas intended to be used for practice wickets should be treated in a similar manner.

CONCRETE AND OTHER ARTIFICIAL CRICKET WICKETS

Very few of the smaller sports clubs or local authorities can afford the laborious routine operations necessary to maintain true and durable turf wickets throughout the season, and as a consequence many are either denied the facilities for playing cricket or are forced to accept very poor and uneven turf wickets with all the risks involved. It is gratifying therefore to note an increasing interest in alternative types of wickets judging by the constant inquiries reaching The National Playing Fields Association for information on their dimensions and method of construction.

Concrete wickets covered with matting undoubtedly seem to be gaining in popularity. Indeed, we are informed by prominent park officials that if the increasing demands for cricket pitches on public playing fields is ever to be met, concrete or other types of artificial wickets will have to be accepted in

spite of the prejudice against them on the part of some players. They point out that quite apart from the difficulties of turf maintenance, the space is not available to reserve a sufficient width of cricket table to furnish the requisite number of match wickets throughout the season.

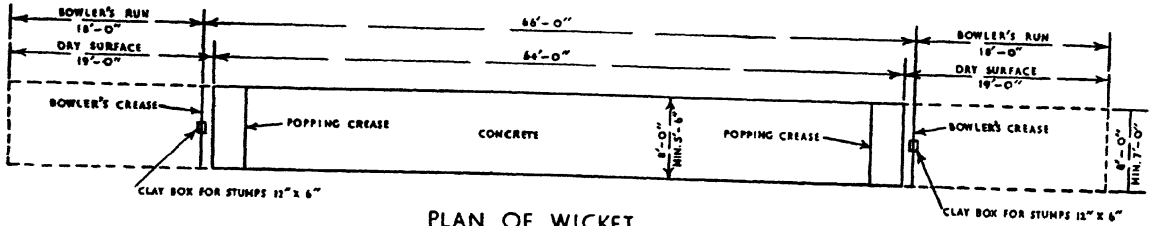
The general adoption of artificial wickets for public play should go a long way in improving the standard of cricket. No player can really become proficient unless he has an accurate surface to play on. Most of our cricketers with overseas experience are convinced that the extensive use of concrete wickets in Australia has been an important factor in producing the all-round excellence of their test sides to which we have become so accustomed. Leading Australian cricketers themselves have publicly acknowledged the advantages they derived from playing on concrete wickets.

Quite apart from their playing properties, however, concrete wickets may allow facilities for cricket to be fitted in where the available margin between adjacent winter games pitches is too restricted to accommodate an independent turf cricket table of sufficient width to provide the season's wickets without overlapping the winter games pitches and thereby complicating problems of management and maintenance.

A typical constructional detail is shown in Fig. 51. Many authorities consider a minimum width of 7 feet desirable but, as the average strip width of coco-nut matting is generally 6 feet, it is best to keep the concrete to 5 ft. 6 in. to allow an overlap of matting for pegging to ground on either side. Where the concrete is wider the matting would have to be made up to the required width to allow the overlap by joining two narrower strips with a seam down the centre of the wicket, and this is objected to by some, although when done properly it should have no appreciable effect on play. Similarly, opinions differ as to the desirability of having a slight camber formation on the concrete to throw off the rainfall. Where a camber is provided it should not exceed ½-inch rise at the centre of the wicket above the level at the sides and this should not noticeably influence the bowling.

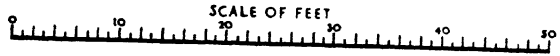
It will be noted that for a match wicket the concrete can be stopped 1 foot short of the bowler's crease at each end. Whereas for a practice wicket 24 feet of concrete is generally considered ample. A 4-inch deep slab of concrete on a 4-inch deep well-consolidated formation of hardcore is normally sufficient, a layer of waterproof paper being provided on top of the hardcore before concreting is commenced. Where waterproof paper is not available the surface of the hardcore should be well wetted before laying the concrete.

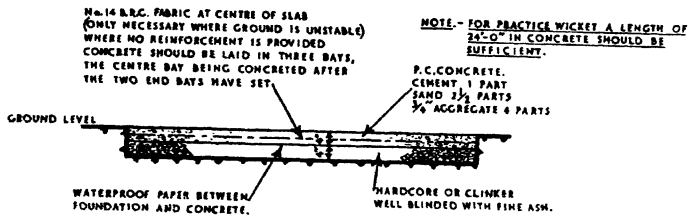
Concrete to be mixed in the proportions: 1 part British standard Portland



PLAN OF WICKET

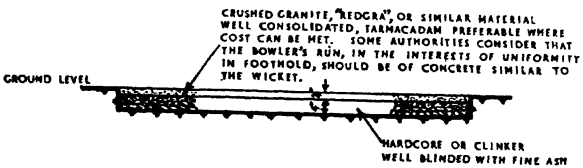
SCALE OF FEET





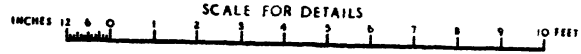
SECTION THROUGH CONCRETE WICKET

NOTE.- AS TURF WILL NOT STAND UP TO THE CONSTANT TRAFFIC OF THE BOWLERS, IT IS BETTER TO PROVIDE A HARD ALL WEATHER SURFACE FOR A DISTANCE OF AT LEAST 18'-0" BEYOND THE STUMPS AS SHOWN.



SECTION THROUGH BOWLER'S RUN BEYOND ENDS OF CONCRETE WICKET

SCALE FOR DETAILS



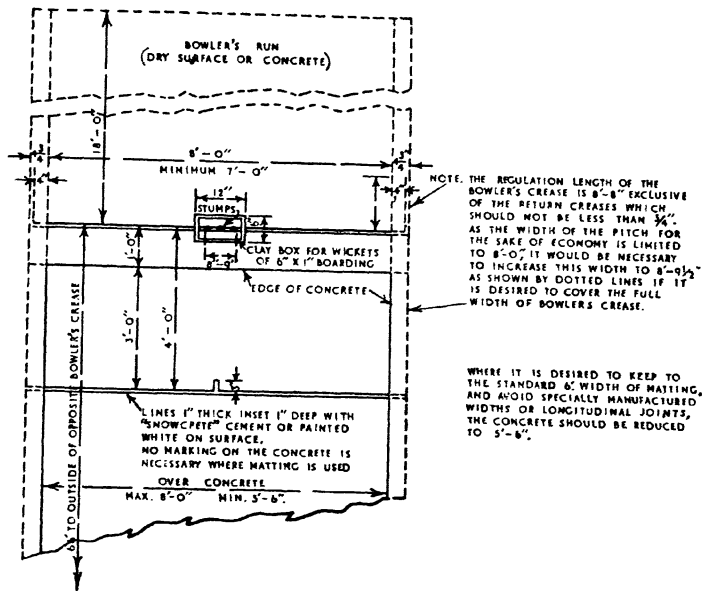


FIG. 51. DETAILS OF CONSTRUCTION OF CONCRETE CRICKET WICKETS

cement, 2½ parts sharp washed sand, and 4 parts of broken stone or other approved aggregate ¾-inch gauge.

Note that where concrete wickets are laid down some type of dry-surface bowler's run must be provided as the turf will not stand up to the constant wear. Tar macadam is probably best where it can be afforded. A box of 6 by 1 inch boarding, enclosing a space 12 by 6 inches, centred on the bowlers' crease with top of boarding level with surface of wicket must be provided and filled with clay for fixing stumps. The marking of lines on the concrete need not be considered where matting is to be used as the crease would have to be marked out on the matting.

Experiments with various types of resilient surfacings to eliminate the necessity for matting are now being carried out and by the time this book appears there will probably be many improved surfaces on the market. It may, however, be difficult to find a permanent economic surface which would resist the action of spiked boots worn by bowlers or batsmen playing on turf wickets and some regulations regarding permissible types of footwear may have to be considered in connexion with hard artificial wickets.

Of course, where matting is used other types of wickets may be constructed such as tar macadam, asphalt, or well-consolidated gravel. All these, however, have to be finished off by rolling and it is not always easy to avoid slight waving of the surface. The screeded concrete surface, on the other hand, can usually be finished with greater uniformity, increases in strength with age, and is therefore more durable.

THE BOWLING GREEN

The ancient game of bowls is one of the most popular recreational pastimes in the British Isles. It is an ideal summer game for adult players of all ages and both sexes. There are two codes previously referred to in the section on 'Space Requirements', the crown game and the rink game, each requiring its own distinctive type of green. Rink or flat-green bowlers are probably the most exacting sportsmen to cater for.

The rink game demands a very accurate flat surface of uniformly dense and finely textured turf. It must be firm and resilient, stable and well drained. To establish and maintain such a surface is, as a general rule, a costly and troublesome business, and it is seldom that greens can be kept in first-class condition and remain self-supporting on the modest green fees normally charged on public playing fields. Indeed, the writer has been repeatedly informed by the managers of well-run private clubs that the bowling greens

could not be maintained adequately solely by the revenue from the club subscriptions. The maintenance funds are invariably subsidized largely by profits from the licensed refreshment bar and other club functions. This aspect must be stressed as there are a large number of parish councils or small village organizations who are too often persuaded to lay down expensive games facilities of this nature without fully appreciating the nature and extent of their commitments in respect of maintenance. It is an easy matter to fritter away in the course of a season or two the appreciable capital expenditure required for the construction of a green if adequate skilled attention is not given after establishment.

Sea-washed-turf greens. Many British bowlers have a deep-rooted conviction that the best games can only be enjoyed on greens developed from turf grown naturally on the sea marshes around our coasts, especially turf from the marshes of the Solway Firth or Morecambe Bay districts, and in many cases classify their greens in the lists of their County Bowls Associations as 'Cumberland Turf' greens or otherwise, even when, after long establishment, it would be extremely difficult to distinguish between a green originally turfed and one produced from a well-balanced mixture of grass seeds. It frequently happens that sea-washed turf when laid in a new location changes in the course of a few seasons the original characteristic texture of its herbage. Climatic or other local circumstances may encourage the constituent and slightly coarser agrostic species to crowd out the finer fescues which are generally more predominant in its natural state and impart to the turf its attractive silky texture. Indeed, it is extremely rare to find turf consignments for a full-size bowling green arriving on the site in a uniform condition, although the greatest care may have been taken in its selection before cutting and lifting. Several days in rail wagons on transit will naturally check the growth, especially of those turves packed in the lower layers, and very often the fescue constituent grasses suffer most. This results frequently in a peculiar patchwork effect on newly laid greens and much skilled attention is required during the early stages of establishment to promote that uniformity of texture which is so essential to a smoothly running green.

Alternative methods of construction. The diagram Fig. 52 shows the more general methods adopted for the construction of bowling greens developed from turf or seed. Sectional detail (1) is based on the original constructional practice for sea-washed-turf greens. It was evolved with the intention of ensuring a playing surface that would drain rapidly after showers, remain stable under normal soil conditions, discourage the action of worms, reduce

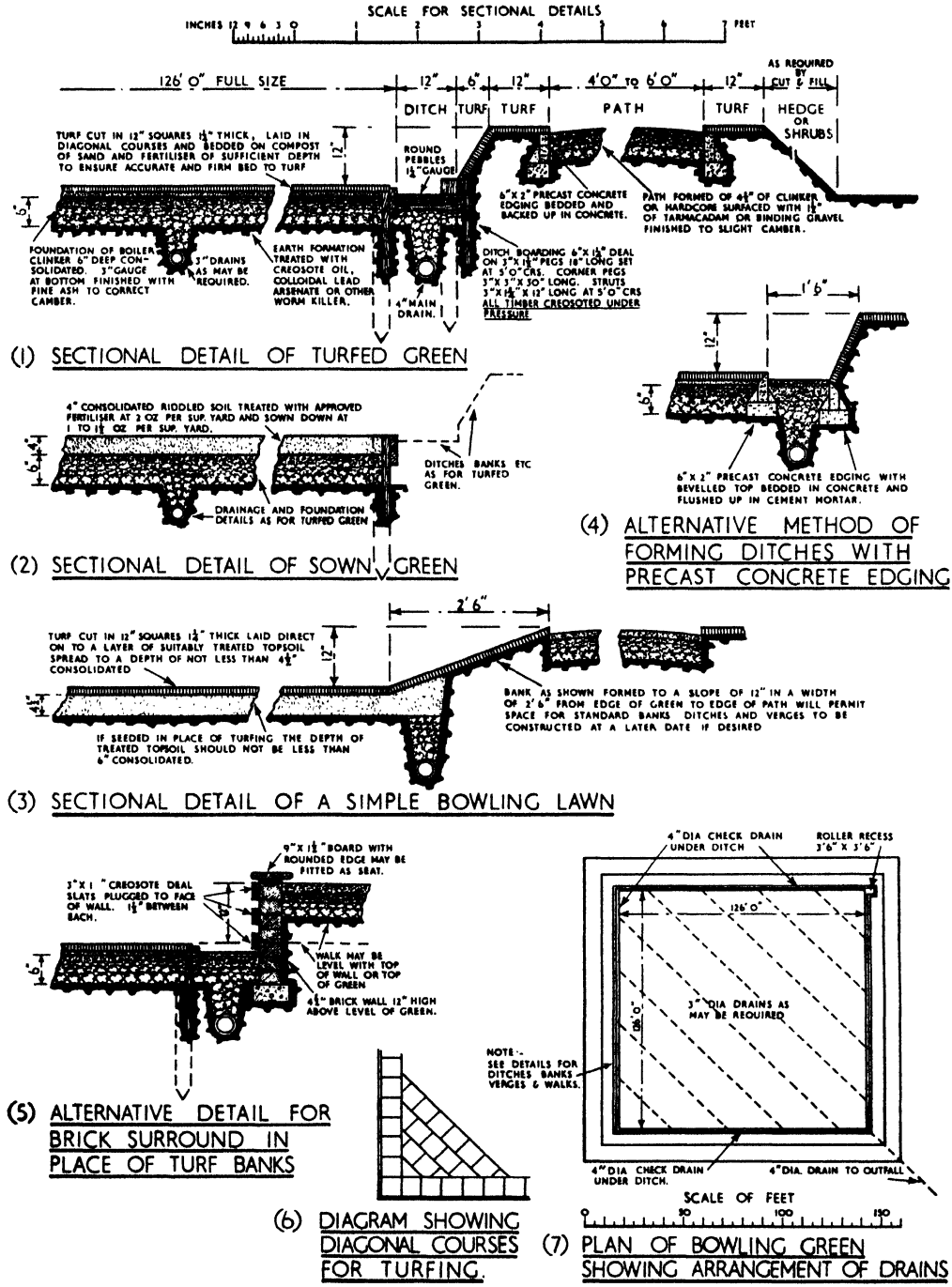


FIG. 52. FLAT RINK BOWLING GREEN DETAILS

the risk of introducing into the formation weeds indigenous to the locality, promote a dense finely textured surface growth, and eliminate all risk of damage to over-running woods.

It will be obvious from the details shown that the means adopted to obtain these results were extremely drastic and hardly conducive to economic methods of turf culture. The formation, originated by old Scottish bowling green constructors, probably met extremely well with the rather wet conditions normal to districts of the north-west of England and south-west of Scotland, but when adopted in drier parts of the country it was difficult to retain the moisture necessary to a healthy vigorous turf. It will be noted that there was nothing in the materials used for the foundation on which the turf could feed naturally and root strongly. Consequently, frequent top dressing and artificial watering became troublesome items in routine maintenance. These practices, in conjunction with the appreciable compression on the comparatively thin layer of soil in the turf caused by heavy rolling and traffic against the strong resistance from a somewhat rigid and unyielding base, engendered complex physical, chemical, and biological conditions which could only be integrated satisfactorily by constant laborious effort. The attempt to assure stability, accuracy, and limitation of risk of local infections irrespective of other basic requirements for good turf culture probably introduced more troublesome defects than those it was hoped to cure, and it is doubtful whether, on the average, the original objectives were ever satisfactorily achieved.

No doubt, in advocating the foundation of clinker or hardcore, the constructors were anxious to obtain not only a quick-drying sward which would be available for play in the shortest possible time after heavy showers, but also to avoid any surface waving likely to arise through rolling on a plastic soil base, quite apart from their fear of introducing weeds with any soil used. The plasticity, however, might be overcome without entirely excluding soil, and as for the danger of weed-infection no natural turf can be obtained which is entirely free from weeds, and those indigenous to sea-marshes are as troublesome to eliminate as any that might be introduced locally during construction.

The usual procedure is to excavate for the earth formation of the green so that the playing area is taken out completely from the solid with no earth filling or make-up underneath. Where the fall in the ground was severe this practice greatly increased the quantities of the earth work and it is doubtful whether in these days of rising labour costs such exacting methods can be afforded. The earth formation nowadays, therefore, would be preferably

blocked out by balanced cut and fill over the playing area of the green, ditches, and surrounding raised walks and borders, as it would probably be cheaper to face the risk of some surface adjustment later rather than incur any disproportionate increase in the initial capital expenditure due to excessive provisions against subsidence. All earth filling should be deposited in layers not exceeding 6 inches deep, well rammed, and consolidated by heavy rolling after each layer until the desired level and degree of compaction is obtained. Where the depth of the filling below the actual playing surface does not exceed 1 ft. 6 in. and adequate compaction has been achieved under optimum soil conditions, there should be little risk of serious subsidence. Where, however, greater depths of filling are necessary, it would be advisable to block out the earth formation and allow a season's weathering for any further settlement to take place before proceeding with the foundation and turfing.

Drainage. After blocking out the earth formation the next operation is drainage. This is most important, especially where the subsoil is of a finely divided tenacious character. Such soil bases, if subject to severe variation in the water content, may, as a result of climatic changes, undergo considerable movement by expansion or contraction. It is therefore desirable to keep the soil conditions as constant as possible by disposing of all free water percolating through the foundation before it has time to saturate the subsoil. Fig. 52 plan (7) shows a typical arrangement of subsoil drains for a bowling green. The direction of the drains are shown by dotted lines. The main drain need not exceed 4 inches diameter and should be laid with the highest point 6 inches below the earth formation at one corner and, running around the green under the ditches, should have a uniform fall to a depth of 1 ft. 6 in. at the opposite diagonal corner from which point the outfall can be connected to the nearest drain, ditch, or to an adequate porous-filled sump or soakaway. Intermediate drains 3 inches diameter would be laid in rows as indicated parallel with the diagonal of the green in the direction of the fall in the main drain. The spacing of these drains may be from 15 to 30 feet apart according to the nature of the soil. Where greens are constructed on gravel or sandy soils into which rainfall penetrates rapidly, there is no need to make any special provision for drainage. Two-inch diameter drains may be used as intermediates if readily obtainable.

Worm Prevention. It is always advisable to take adequate steps to discourage the action of worms and similar pests working upward throughout the green. Wormcasts can be a great nuisance on fine turf areas. Crude creosote oil sprayed over the subsoil formation before building up the green is very

effective. The rate of application should be approximately 1 gallon to every 10 superficial yards of surface and if the weather is dry the soil should first be well saturated with water to drive the air from the interstices, so that when the oil is sprayed it will be more effectively absorbed. Creosote is also effective in checking the growth of weeds on the formation surface.

An alternative worm killer which is very effective is colloidal lead arsenate. Mixed at the rate of 2 lb. to a gallon of water, this quantity should be applied to every 25 superficial yards of surface. As before described, the soil should first be well watered before applying the mixture.

Ditches. The ditches round the green are preferably framed of timber. The outer and inner boards being of 6 by 1½-inch sawn deal securely fixed to 3 by 1¼-inch pegs 18 inches long, pointed, and driven into ground at centres not exceeding 5 feet apart. Corner pegs are usually 3 by 3 by 30 inches long. Ditches need not be more than 12 inches wide between the boards which are braced apart at 5 feet centres by 3 by 1¼-inch sawn deal struts of the required length. It should be noted that the inner board is set to finish with its upper edge ½ inch below turfed level of green or flush with the soil level in the case of seeded greens. The outer ditch board is usually set 1½ inches above the inner board level to allow a standard 12-inch turf to be laid on the face of the bank (see Fig. 52, details (1) and (2)). All timber used should be thoroughly creosoted under pressure.

Restrictions on the use of timber make it necessary in some cases to substitute concrete edging and an alternative arrangement is shown in Fig. 52, detail (4). If this edging is finished with a bevelled upper edge the turf can be fitted to project slightly above the edging and eliminate all danger of overrunning woods being damaged by coming into violent contact with the concrete. Where standard precast rectangular edging is used the turf would have to be laid over the edging with consequent risk of crumbling along the edges of the green. *It will be observed therefore that timber-framed ditches are much to be preferred as there is no risk of damage to woods, and, furthermore, as the level of the green gradually rises in the course of time with repeated top dressings a fillet can be nailed to the upper edge of the boarding to maintain support to the edge of the turf.*

The ditches formed by the boarding are bottomed with boiler clinker and topped with a layer of round beach pebbles 1¼ to ¾-inch gauge. The top of the pebbles should be 1½ inches below the level of the playing surface.

Foundation. The defects of the standard method of construction have already been discussed and except in districts of very high rainfall the foundation could with advantage be improved by providing a layer of boiler clinker to a

depth of 3 inches consolidated, covered with a layer of good loamy soil and fine clean clinker ash (through a $\frac{1}{2}$-inch riddle) well mixed and spread to a consolidated depth of 3 inches. No pieces of clinker larger than 3 inches should be allowed in the lower layer and any larger pieces should be broken up.

The inclusion of soil with the upper layer of the foundation will furnish a more suitable base for healthy rooting and will allow fertilizer and manurial applications to be retained to a greater degree and their action in consequence more sustained. It also provides a more suitable medium for the bacterial activity so essential to the breaking down of the various chemical applications into a form more readily assimilated by the plant roots, and the addition of the clinker grit increases the frictional resistance to movement of the soil particles and therefore reduces the risk of appreciable surface movement under rolling. Indeed, the deeper the roots can strike the less serious will be the adverse effects of heavy rolling as the pressure will be transmitted through a greater depth.

Turfing. Sea-washed or other bowling-green turf is lifted in 12-inch squares and normally boxed to a uniform thickness of $1\frac{1}{4}$ inches before being put on rail. This thickness has generally proved the most suitable for handling and transport without excessive loss by breakage. The turf on arrival should preferably be laid out flat if there is sufficient room for this to be done. If space is limited and consignments have to be stacked, deliveries should be arranged so that stacking for more than two or three days is avoided.

Before turfing is commenced, the finished surface of the foundation should be carefully checked for accuracy and any irregularities made good. The turves should then be carefully examined as it frequently happens that however carefully they may have been boxed before dispatch, there are noticeable variations in thickness on arrival, due in many cases to pressure arising from stacking in the wagons during transit. It is wise therefore to determine the finished level of your green above the completed foundation level by laying down one of the thickest turves and carrying this level throughout the green area by driving in firm wooden pegs at 8 feet centres on which the turf levels may be checked from time to time with a 12 to 14 feet long wooden straight-edge and spirit-level as the work proceeds.

Turfing should commence by laying a single row along the edges of the green, the area within being turfed in diagonal courses as shown in Fig. 52, detail (6). Some like to specify a layer of sand 1 inch deep for bedding the turf, but the sand in no way adds to the growth of the turf and is only a clean and convenient medium for adjusting any irregularities in the thickness of

the turves, and any excessive depth may result in a varied reaction under rolling. The firmer and more closely the turf is bedded on the foundation, the more stable will be the surface. The turf can be bedded quite effectively direct on to the soil and ash base but unfortunately many of the older and more skilful turfers prefer to use sand as they work on their knees when turfing and complain that the clinker grit works into the knee-pads and irritates their knees, but sand does not. It is well worth while considering the wishes of the constructor in this respect, as he will probably give the best results working with the media he finds best suited to his method. The main object is to ensure that any adjustment to maintain an accurate surface level is made by raking out or packing in the sand or mixture of soil and fine clinker below the turf to ensure the right level and not attempt to secure surface accuracy by excessive surface beating. A light tap or two with the turfing mallet is all that is necessary to bed the turf firmly where proper adjustment has been made below.

As the turfing proceeds the prepared bed, whether of sand or fine clinker and soil, should be top-dressed with a well-balanced grass fertilizer at the rate of 2 oz. per superficial yard and pulverized peat at the rate of 4 oz. per superficial yard, lightly raked in to encourage quick rooting of the turf. After the turf has been laid it should be finally top-dressed with sharp washed gritty sand ($\frac{1}{8}$ inch down) at the rate of 6 lb. per superficial yard, and, if the turf is of a very silty or heavy nature, powdered vegetable charcoal at the rate of 6 oz. per superficial yard, evenly distributed over the green by lightly dragging over with the drag-brush, taking care to work top dressing well into the joints. The turf should then be left to strike before any heavy rolling is given. The surface, however, must be carefully watched in the initial stages and any joints showing signs of opening up through contraction of the turves as a result of dry or frosty weather, should be filled with fresh sand as soon as circumstances permit. Work on the green, however, should be suspended when the turf is in a frost-bound or saturated condition.

When the sand has worked into the turf, either by the action of rain or frost, further light dressings of sand at half-rate should be given as necessary, until the joints have knitted together. An occasional drag over lightly with the drag-brush when the green is in a fairly dry condition, will help to aerate the surface, work in the top dressings, and stimulate the growth. If the top dressing is allowed to lie too thickly at the base of the herbage and hold the moisture there in wet weather, the growth is liable to rot and weaken.

When the turf has shown definite signs of healthy growth and is beginning

PLATE 22. *Sea-washed turf marsh. Scything over rough areas in preparation for mowing*

PLATE 24. *Sea-washed turf marsh. 'Ritting' or 'racing out' the turf in strips of required width*

PLATE 25. *Sea-washed turf marsh. Turf-lifting in progress*

to knit well, rolling may begin. A single-cylinder steel roller, 4½ cwt. in weight, 30-inch diameter by 30 inches wide with balanced handle and roller bearings, should be used. After completely rolling in one direction, the operation should be repeated in the transverse direction. This rolling with the heavy roller should only be carried out sparingly when the green is in a fairly dry condition to ensure firm contact between the roots and the soil. If carried out too frequently or under wet conditions, the soil may become too compact, with a more or less sealed surface through which air or water will find it difficult to penetrate. As a consequence, the complex activity in the soil is impaired and root growth checked, and unless deep spiking or piercing is immediately carried out the turf may be killed. Probably more harm is done to newly made lawns or greens, whether produced from turf or seed, by the unintelligent use of the roller than by any other cause, and every care should be taken to ensure that it is used only when necessary.

Banks and verges. Fig. 52, detail (1) also shows the usual banks and verges provided as a check to over-running woods on the external side of the ditch. The English Bowling Association at one time specified 18-inch banks, but it will be found in practice that the majority of greens have only 12-inch high banks as shown. Eighteen-inch high banks are very trying for more elderly players, and stepping down from such a height repeatedly is neither good for them nor for the edges of the green. The normal practice then may be taken as a 12-inch bank with a batter of 6 inches from the vertical. The banks and verges are shaped with soil removed from the formation of the green and turfed with turf similar to that used for the playing area. Turves on the banks are generally pegged to the soil by wooden skewers to hold them in position until the turves have rooted. There is usually a 12-inch wide verge round the top of the bank.

Banks and verges constructed in this manner are extremely difficult to maintain in a satisfactory condition. They require constant attention to keep them in proper alignment and there are always at least two sides where the banks get little or no sun in summer, so consequently the growth is variable. If they are to be properly maintained, it means the green-keeper has to give a great deal of time to them which can ill be spared from the playing area. On the other hand, if neglected, they rapidly disintegrate and become a hotbed for weeds and a source of infection to the green itself. Whether in these days of increasing costs such unsatisfactory methods of construction will continue to be preferred in official circles, remains to be seen, but many clubs are becoming disgusted with the fruitless labour necessary to maintain these

surrounds and are seeking more permanent alternatives which will allow their green-keeper to concentrate his energies where they count most. Various arrangements of timber-faced banks have been tried, but these unless closely framed and braced have a tendency to warp and lose their alinement. Probably the most satisfactory surround is the dwarf brick wall (or concrete if preferred) with timber slats along the face to prevent woods coming in violent contact with the brickwork and becoming damaged. This arrangement is indicated in Fig. 52, detail (5), and provides a much more stable support to the embanked walks, or if preferred, the walks can be constructed on the same level as the green with a consequent reduction in earthwork. Some bowlers have the mistaken idea that this structure may seriously damage their bowls. When it is remembered, however, that bowls are generally fashioned from lignum vitae or similar very hard woods and the slats along the face of the wall are of creosoted soft wood, it should be obvious that in the event of violent impact, it is not the bowls that will be dented. If preferred, coco-nut matting could be draped over the face of the wall as a protection instead of the wood slats.

Walks. All greens should be surrounded by walks 4 to 6 feet wide, bottomed with clinker and surfaced with tarmacadam, binding-gravel, or stone-paving as may be desired. Gravel or tar macadam surfaces are always more durable if given good lateral support by means of a well-set edging. This will check any lateral spread through pressure by traffic or rolling which otherwise might result in cracking and disintegration of the surface, demanding more frequent renovation than is required by actual wear.

External banks and borders. These are generally dressed off to a conveniently stable batter as may be required by the cut and fill, dug over and planted with a thick hedge or as a shrub border. A 12-inch-wide turf verge may or may not be provided if the path is edged with concrete.

In planting the surrounds of a bowling green no large trees should be included whose branches on development would overhang the green or whose underground roots would eventually undermine the stability of the foundations. Dwarf trees and shrubs or a good hedge surround to provide shelter and wind-break are valuable both to green and players and further help to isolate the green from any adjacent areas of coarser turf.

Nursery. Wherever practicable, an area should be prepared as for the playing area of the green on some convenient site in the borders where a stretch of turf may be laid as a nursery for patching purposes when required. It should not be less than 20 superficial yards in extent.

Roller recess. The ditch round the green should be widened out in one corner of the green to measure 3 ft. 6 in. by 3 ft. 6 in. to provide a recess for the heavy hand roller.

Alternative for sown bowling greens. Fig. 52, detail (2), shows the formation for a sown green. The levelling, drainage, formation of ditches, would be carried out as for a turfed green with a clinker foundation from 4 to 6 inches deep as may be required by the nature of the soil.

The inner ditch-board it will be noted must be set to coincide with the finished surface-level of the green. The soil bed covering the foundation should be finely screened to remove all stones, roots, and other detrimental matter, and mixed with from 15 to 30 per cent. of sharp clean sand according to the nature of the soil, and spread over the playing area of the green to a consolidated depth of not less than 4 inches.

The surface must be brought to a true level and top-dressed with suitable grassland fertilizer at the rate of 2 oz. to the superficial yard. Where the soil is lacking in humus a dressing of from 4 to 8 oz. of pulverized peat can be given with advantage. These dressings must be well incorporated with the upper layer of soil by raking, after which the surface should be screeded over again to correct levels and consolidated by light rolling.

The surface can then be seeded with the following mixture at the rate of $1\frac{1}{2}$ to 2 oz. per superficial yard:

80 per cent. Chewings Fescue.
20 per cent. Agrostis tenuis.

Seeds to be lightly raked in to give cover, lightly covered with clean sand, and left to strike.

It is important that seeds should be of recent harvest and every care taken in sowing to ensure even distribution.

The banks and verges if provided, should be turfed with local meadow turf as it is impossible to establish seeded banks at the standard profiles. Otherwise the surrounds should be completed as described for turfed greens.

Bowling lawns. In smaller villages where the cost of a green to the usual specifications cannot be faced, provision for bowls can be made by laying down a level lawn with banks of 1 to $2\frac{1}{2}$ slope beyond the actual playing area as shown in Fig. 52, detail (3). These lawns may be turfed or sown as may be expedient, and if drains are provided at the edge of the playing area as shown, then it would be a simple matter to convert to a standard green with ditches and banks later, should the demand arise.

Quality of turf. Sea-washed marsh turf is generally preferred for bowling-green construction, but there are many classes of hill or moorland turf which can be worked up into first-class greens. Many excellent greens were made in Hampshire and neighbouring counties before the war with turf from the Hampshire Downs. It must be understood, however, that there is no natural turf free from weeds and many of the weeds indigenous to sea marshes are as troublesome to deal with as those found in inland meadows.

Samples can be deceptive, as it is a simple matter to pick a square foot of excellent-quality turf from any marsh or meadow which would in no way represent what might be expected in bulk deliveries. Wherever practicable, the source of the turf should be inspected in its natural state if a fair appraisal of its value is desired. Where this is not convenient, and a judgement has to be made purely from examination of samples, do not look only at the grass side. Look underneath and tear the sample apart, when you will be able to distinguish any coarse roots among the finer grass roots and know what to expect.

Many of the coarser weeds in sea turf such as sea-pinks, plantain, and the like shed their foliage in winter and their presence may not be detected in samples lifted at this period unless from the underside of the turf where their roots can generally be seen.

As a rule, however, if the turf has a fairly dense vigorous root mat and grasses of fine texture, it can be accepted and weeds dealt with after establishment by selective fertilization or grubbing up as may be most expedient.

There are certain sea-marshes, however, where the growth becomes silted over, and before it dies off a fresh growth breaks which in turn becomes silted until a layered strata of fibre is built up with little soil distributed throughout the root mat. The texture of the herbage is often very fine and attractive but the spongy nature of the turf is difficult to work up to sufficient firmness for bowls. It is better to avoid turves of this nature. In examining turves see that the root-growth is strong but well distributed through a dense layer of soil.

Typical operations on a sea-washed turf marsh are shown in the following photographs taken on the well-known Lancashire marshes of Messrs. Maxwell M. Hart, Ltd. of Glasgow to whom the author is indebted for permission to use them.

Plate 22. Scything over rough areas preparatory to closer mowing by motor mower. Plate 23. Close mowing by motor mowing in readiness for lifting. Plate 24. Racing out or ritting the turf to required dimensions. Plate

25. Lifting and stacking ready for boxing. Plate 26. Boxing to uniform thickness. Plate 27. Turves transported by bogies to roadside being loaded into lorry for transit to site or rail depot. The effect of stacking on the lower layers of turf during transit may be appreciated. Speedy transit is very desirable if growth is not to be checked by prolonged pressure and lack of air. The importance of avoiding further stacking on arrival should be understood.

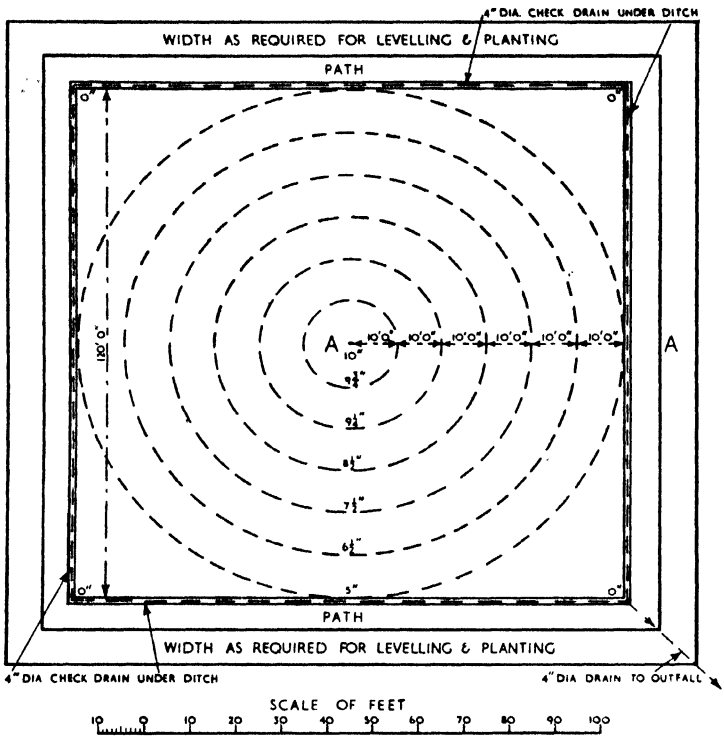
Turf versus seed. The argument is generally put forward that turfed greens are ready for play long before seeded greens, but in the writer's experience too much depends on the climatic conditions prevailing during and immediately following the completion of the work, the skill and experience of the constructor, and the location of the green to arrive at any definite conclusions in the matter. On many occasions the opening of turfed greens has had to be deferred for a whole season because the construction work has been hampered by severe frost or heavy rain, and abnormally dry weather has followed the completion of the work, which has seriously retarded recovery and knitting of the turves. On the other hand, a green sown in the autumn, which gets away to a good start under a mild spell of weather, will often develop sufficiently by the following midsummer to allow limited play to commence.

The main advantage of turfing is that you can obtain as a rule a more stable and accurate surface than by seeding. The turfed surface is not so liable to subsidence under heavy rains as invariably occurs on a seeded soil which cannot offer adequate resistance to such disturbing forces until a suitable root mat has been established. Seeded greens therefore may require some surface adjustments to be made by means of light top-dressings over a season or two to correct slight depressions caused by unequal settlement. With patience, however, first-class greens can be developed from seed at probably half the cost of turfing.

It should also be remembered that turfed greens will play a little bumpy for a season or two till the turves are thoroughly knitted and the green is able to settle down uniformly.

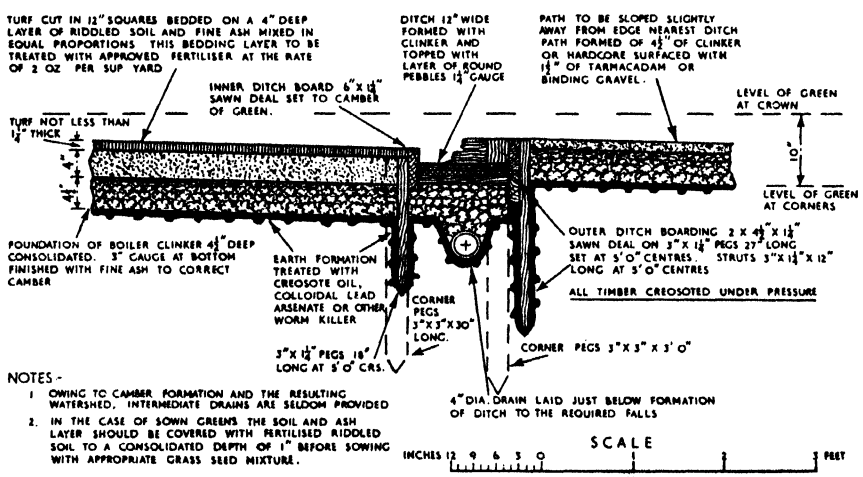
CROWN GREENS

The formation contours for a crown bowling green are indicated in Fig. 53. The green should have approximately a parabolic convex surface, with a maximum rise of 10 inches above the corners. The crown formation should be uniformly maintained from the earth formation upwards and on account of this shaped formation it is unusual to provide drains under the green. A drain under the ditches is normally adequate.



PLAN OF GREEN

SHOWING CONTOURS OF CROWN ABOVE CORNERS OF GREEN



SECTIONAL DETAIL A-A

FIG. 52 ORDINARY ROUNDING GREENS

From the detail it will be seen that banks and verges are not favoured, but the inner ditch-board is set to a raking slope with a 5-inch rise at the centre over the level at the corners to correspond with the fall in the corners of the green surface. The outer ditch-board should be set to a true level with the edge of the surrounding walk at about 1½ inches above the inner board at the centre or approximately 6½ inches above the inner board at the corners. It is therefore better to have two boards 6 by 1¼ inches set on edge to give a total depth of 12 inches so as to provide adequate support to the outer side of the ditch.

Otherwise it will be seen that the construction for turfing or seeding is mainly as before described for flat greens, except that as woods are thrown in any direction there is no object in turfing diagonally and the turf may be laid in parallel rows.

Crown bowlers are not so fastidious as rink bowlers and do not object to minor inaccuracies or 'tricks' as some call them, in the finished surface, which they may get to know and exploit against visiting opponents.

HARD TENNIS COURTS

The immense popularity of the game of lawn tennis stimulated an intensive search for an alternative surface to grass which would be less subject to the limitations on play imposed by the vagaries of the climate. Consequently there is now a wide range of hard-court surfacings of varying type, but the decision as to the most suitable for any particular circumstance must depend largely on local preference and financial capacity. Quite apart from comparative playing properties, the durability and maintenance implications inherent to the different surfaces may be an important influence in choosing a hard tennis court, where economic considerations cannot be entirely overlooked.

Whatever may be the proprietary names given to various hard tennis courts, their construction falls mainly into three groups.

1. The rubble, loose-surface, or waterbound court; generally formed of suitably graded crushed rock, gravel, shale, or brick dust, and depending to a large extent on hygroscopic influence to maintain a well-bound surface.
2. The semi-permanent court generally consisting of a thinly gritted surface dusted loosely over a foundation layer premixed or grouted with tar or bitumen:

3. The permanent, rigid, and frequently termed 'non-upkeep' surface, which is usually some modified form of highway construction such as tar or bitumen macadam, or concrete.

For courts of the first type it is claimed that the bound of the ball closely resembles that of the ideal grass court; that the surface is 'resilient' and more comfortable to play on than other types of hard courts; that rainfall is readily absorbed and drained away through the porous structure; also that in hot weather heat is not retained to the same extent as on the more rigid surfaces and consequently they are less heating and tiring to the player's feet. They are of course much cheaper to construct and it is further claimed that the wear on the balls is less severe than on surfaces of a more cohesive character.

Whether the term 'resilient' can be accurately applied to surfaces of this nature is extremely doubtful. 'Resilience' according to the *Oxford Dictionary* means 'power of resuming the original form after compression; elasticity.' These loose surfaces certainly give under the feet of the player but this can hardly be claimed as 'resilience' as the surface remains disturbed after the pressure is removed. Indeed, the frequent redistribution of the surface grit by the use of the drag-mat, drag-brush, or squeegee, followed by watering and rolling are essential operations to maintain a true playing-surface. The amount of watering, dragging, and rolling will depend of course on the grading and layering of the surfacing material to obtain a good mechanical bond between the particles in addition to any hygroscopic qualities of the materials used and the extent to which the retention of surface moisture may be augmented by dressings of chemical deliquescents.

It will be obvious, therefore, that if the ideal playing properties of a good grass court are to be reproduced on a hard court, the amount of maintenance effort required will not differ to any appreciable extent. Rolling and watering will be common to both. Top-dressing with fertilizer and reseeding or patching of grass courts will be offset by frequent applications of deliquescent chemicals and replenishment of fine grit to worn areas as may be necessary on hard courts of this type. Occasional piercing of the surface when packed too tightly by traffic or rolling to restore porosity to the hard court is, of course, similar to the piercing of grass courts necessary to maintain effective aeration of the soil. The regular mowing of grass courts is counterbalanced in the case of hard courts by the dragging operations referred to above.

Waterbound surfaces of this nature are, however, difficult to maintain in

good playing condition during freezing or thawing. Applications of salt are often effective in overcoming these difficulties provided they are not washed out by heavy rain before frost occurs and this is by no means easy to arrange in a variable climate such as ours.

The decision therefore as to whether or not the ideal playing conditions offered by courts of this type can be considered as paramount must depend on the amount which can be raised locally to cover the cost of the regular maintenance operations. This aspect of maintenance may be of secondary import to the larger and wealthier clubs, organizations, or public authorities. In the case of smaller communities, however, it is generally a matter which calls for the most serious consideration. Too often many are tempted by the lower initial expenditure to instal courts of a type beyond their capacity to maintain efficiently with the result that the surface rapidly deteriorates and costly renovation becomes necessary if they are not to become derelict.

The second type of court was devised to give somewhat similar playing properties to those of the waterbound court by providing a thin dressing of grit on a stabilized base. The subsurface layers are bound by bituminous or tar emulsions and are therefore not dependent on film moisture for adequate adhesion. Thus daily watering and rolling are eliminated, while the dusting of grit over the surface affords a greater freedom of footwork than is possible on the more rigid surfaces. There is also no surface disturbance to any appreciable depth as might occur on many types of waterbound courts if play takes place under very dry conditions. The loose surface grit, however, should not be too hard, coarse, or spread too thickly or the abrasive effect under the shoes of the players may induce rapid wear on the service lines and similar areas subject to concentrated traffic. While daily attention is unnecessary it may be advisable at times to drag the surface to redistribute the grit which may be worked or blown to the sides or ends. The marking-lines also may require brushing or touching up, as the occasion demands, as the markings for these and waterbound courts are frequently of lead or plastic strips and must be kept clear of grit.

These courts are naturally more expensive to construct than the waterbound rubble court but are not so costly as the more rigid types of hard courts.

The third type of hard court referred to above is usually constructed of tar or bitumen macadam, asphalt, or similar modified forms of highway surfacings. It is the most expensive to construct but when well done results in a rigid, immovable surface which will last for many years without daily

attention. The surface can be finished in any desired colour by spraying with a suitable paint after the volatile oils have weathered out from the binder. Alternative to spraying is to roll in with the final rolling any suitable granular material of approved colour. The playing-lines are usually marked out with aluminium paint or white road-line enamel.

The main purpose of this method of construction is to produce a playing surface which will require no daily attention and naturally certain playing properties may be impaired in the achievement of this objective. First, the bound of the ball is somewhat different to that which might be expected from a surface with less grip. Then again the resistance to sliding footwork is much more severe and furthermore such surfaces retain the heat of the sun to a greater extent than on loose surface courts, and players find them more exhausting to play on. Some claim also that tennis balls wear out much more rapidly on these courts, but the writer has heard so many different opinions expressed on this aspect by experienced players that it would appear as if any disadvantage in this respect can only be very slight.

Despite the objections raised there can be little doubt that such hard courts do provide facilities for tennis in many circumstances where the maintenance contingent on the provision of other types is impracticable. For this reason their popularity is increasing in those localities where no regular and experienced groundsman can be employed.

Some of these courts are finished with a smooth impervious surface, while others are preferred with a coarser grade of topping to give a fairly open porous surface texture. The latter method of tar macadam surfacing is contrary to good highway practice where a sealed surface is considered essential to retain the self-healing plasticity of the binders used for coating the aggregate. When exposed to the atmosphere for any length of time the binders lose their plasticity and become brittle, and if the aggregate composing the surface has not been skilfully graded, layered, and compacted to ensure efficient interlocking, the surface may rapidly break up after weathering. Where, however, a stable porous surface can be obtained it does provide a more comfortable foothold as the air in the interstices cushions the tread to some extent.

Although these courts are frequently described by various makers as 'non-upkeep', there are few cases where after an interval of two or three years, respraying with binder emulsion and retinting may not have to be taken into account, depending on the method of construction, quality, and grading of the aggregate, degree of compaction, intensity of play, and climatic condi-

tions. Some annual allowance should therefore be made against such a contingency.

Tennis-court gradients. Porosity in the construction of hard courts is a great asset but whatever the type of court it is not easy to maintain this condition indefinitely. Quite apart from the effects of increasing compaction by play and maintenance traffic, there is always a certain amount of windborne dust or grit which settles on the surface and eventually works in and clogs the interstices. This condition can be easily remedied by piercing in the case of loose-surface courts as the occasion demands, but this is not so practicable with the more cohesive types of surfaces. Consequently all courts with more or less fixed surfaces should be laid with a uniform surface gradient sufficient to shed the rainfall fairly rapidly and allow the surface to dry out quickly after showers. It is generally accepted that this gradient should not exceed 1 in 120, but this is hardly sufficient as it is not practicable to ensure that surfaces of this character will not show slight depressions after the final rolling. For public tennis courts a maximum grade of 1 in 60 should not seriously affect the class of play to be expected and would certainly increase the playing time during inclement weather. It must be stressed, however, that any gradients given to the surface of hard tennis courts for this purpose should always be transverse to the main direction of play and never longitudinally nor from centre net line to each end.

Levelling. In blocking out the formation of tennis courts the same care should be exercised as for bowling greens to ensure that all filled areas are thoroughly compacted and there is no liability to future subsidence. All vegetable matter and organic soil should first be stripped from the site and the earth formation treated with strong concentrated solutions of weed-killler, every effort being made to secure uniform distribution throughout the area and adequate penetration of the fluid. If weeds germinate and work upwards from the subsoil after construction is completed extensive damage may be caused.

Where levelling involves an appreciable depth of fill it is best to block out the earth formation and allow a season for weathering and settlement before proceeding with the actual construction of the court.

Drainage and foundation. Good drainage and an adequate foundation of suitable dry filling are essential to the stability of any hard court. Disastrous results may follow from frost heave where water is still retained below the surface when frost sets in. Also where clay subsoils are allowed to become saturated from time to time there may be appreciable movement affecting

the bearing of the foundation. It is therefore wise to make generous provision for any free water which may penetrate to the soil base to be led off as rapidly as possible.

Drainage is often arranged by means of a main drain running diagonally across the area and collecting from intermediate drains as may be required running on one side of the main drain in rows parallel to the sides of the court and on the other side of the main in rows parallel with the ends of the court to form a herringbone system. The writer prefers the grid-iron system with the main drain laid round the court or courts just inside the line of the stop netting, with the intermediate collector drains spaced in parallel rows with the sides or ends of the court as may be most expedient. This method more effectively traps and diverts any water coming in from higher ground adjoining where excavation has taken place and also checks any seepage which may weaken the banks at the limits of the filled areas.

Four-inch diameter land drains are usually adequate for the mains and 3-inch diameter for the subsidiary collector drains. Two-inch diameter drains are quite suitable for subsidiary collectors and may be used for economy where obtainable. During the war their manufacture was discontinued in certain areas. Pipes should be laid to adequate falls and the trenches back filled with suitable hardcore to the level of the earth formation as described for bowling greens. Where courts are constructed with impervious surfaces there is of course no need to provide intermediate drains below the court but a drain around the boundaries is very desirable where the subsoil is of a retentive character.

Spacing for subsidiary drains should be from 10 to 20 feet apart according to the nature of the soil. In setting out these drains care must be taken to see that they are so spaced as not to hamper the correct fixing of the tennis-net post sockets.

In preparing foundations for hard courts there is often a tendency to cut costs by reducing the depth. This practice cannot be recommended unless where the subsoil is of a firm, dry, clean, and permeable character such as natural gravel when a shallow blinding layer of fine clinker or other suitable fine material may be sufficient to ensure a true and well-compacted base. In normal circumstances a foundation of clinker or other suitable dry filling to a total consolidated depth of at least $4\frac{1}{2}$ inches is advisable, while on clay soils a minimum consolidated depth of 6 inches would not be extravagant.

Graded material is best where it can be economically obtained, but here again the practice of saving money by using mixed boiler clinker and ashes,

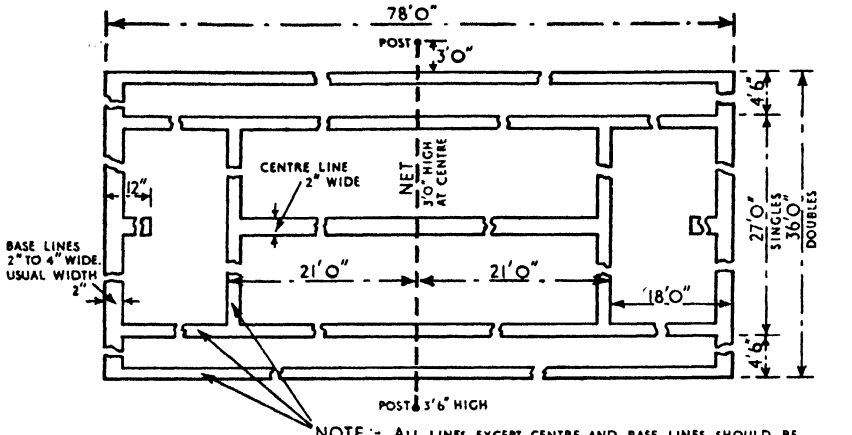
and depending on hand raking to produce a satisfactory arrangement of the foundation, with the coarser material at the bottom and the fine on top, is very prevalent. This method places too much reliance on the skill and integrity of the constructor and the results are often extremely variable. If mixed clinker is to be used it is much better to separate sufficient fine material by throwing through a ¾-inch-mesh screen and laying down the coarse material, breaking up any large lumps to sizes of from 2½ to 3-inch diameter; raking, levelling, and rolling to a uniform depth; and finally blinding with the fine stuff to obtain a level, well-knit, and compacted surface.

The more thoroughly this grading of the foundation structure can be done, the more evenly will the pressure be distributed over the subsoil with consequent greater uniformity in the reaction of the surface under rolling and traffic. Quite apart from this aspect of stability, however, there are occasions when it becomes necessary to pierce courts of the waterbound type and if the foundation layer is not reasonably graded piercing at close centres to a sufficient depth may become impracticable.

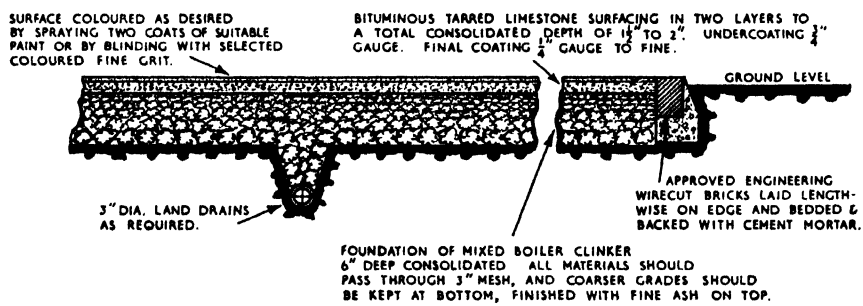
A good edging must be provided to all hard-court surfaces to resist any tendency to lateral spread under pressure of rolling. Hard well-burnt non-absorbent engineering bricks laid lengthwise on edge and bedded, jointed, and faced up on the outer face in cement mortar provide a durable support. Precast concrete edging may be used as an alternative. The edging should be fixed with the upper surface flush with the finished levels of the court. Typical sectional details are shown in Fig. 54.

Hard-court surfacings. Waterbound rubble types: as previously described these may be formed of a wide range of crushed rocks or other hard structural materials of varying colours. Granite, red shale, slag, and brick-dust are probably the most commonly used according to the preference of the various specialist constructors. They are screeded over the foundation to a uniform depth of from ¾ to 1 inch on the average and watered and rolled.

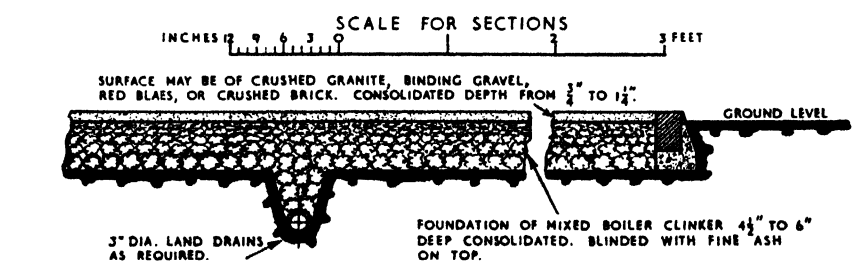
Brick dust was probably the most widely used at first and produced a surface of warm red colour, free from glare, and comfortable and accurate in play. If the quality of brick used for crushing was of the high grade, red engineering type, fairly long service might be expected but, in an endeavour to cut costs, many constructors would purchase for crushing any old bricks or tile of suitable colour, with the result that the crushed material showed considerable variations in quality. Where the materials had been prepared from poorly burnt brick or tile, it rapidly degenerated on weathering and produced a sticky surface that picked up readily on the shoes of players in



REGULATION MARKING FOR TENNIS COURTS



SECTIONAL DETAIL OF PERMANENT HARD TENNIS COURT (TARMACADAM TYPE)



SECTIONAL DETAIL OF LOOSE SURFACE WATERBOUND HARD TENNIS COURT

FIG. 54. HARD TENNIS COURT DETAILS

wet weather, and was blown about badly by high winds when dry. Consequently the maintenance of such surfaces became laborious and costly, and efforts were made to improve them by using materials of a harder and heavier nature like crushed granite, or those with good natural binding qualities such as marly gravels or fine slag.

Such improvements as were effected generally led to disadvantages in other respects such as poor colour causing glare from the intense reflection of sunlight or, where the retention of moisture and good binding properties were satisfactory in periods of drought it invariably meant that the court surface took much longer to dry out sufficiently for play after rain, and often opened up badly in frosty conditions. In the writer's opinion the main fault with this type of surfacing is the attempt to simplify construction and labour costs to the minimum by using a material of sufficient fineness to be screeded on in one layer. The granular texture, therefore, is seldom sufficiently varied to secure interlocking of the particles during compaction and too much reliance for surface cohesion is placed on hygroscopic attraction.

Lately there have been many improvements in the methods of colouring these surfaces to overcome any inherent defects from glare by finally dusting over with materials of good natural colour or which have been impregnated with suitable pigments at high temperatures. Spraying with coloured solutions is seldom effective for any reasonable length of time.

Probably the best method of construction for loose-surface courts was that practised many years ago in Scotland, where the principal material used was well-burnt red shale (blaes) or red ash from colliery tips. This was generally applied in three layers. The first consisted of $\frac{3}{4}$ to $\frac{1}{4}$-inch gauge material spread to a uniform thickness of 1 inch, and this was covered with a layer of $\frac{1}{4}$ inch to fine material spread to a depth of $\frac{3}{8}$ inch, carefully levelled, watered, and rolled after each layer and finally blinded by applying fine stuff passing $\frac{1}{16}$-inch-mesh screen applied in three or four light dustings well brushed and watered into the interstices and finally dusted over to leave a smooth, true, well-bound surface. With the best types of court the material used for the dusting was a specially prepared fine dust obtained from crushing the best-quality red engineering brick. It will be recognized at once that a well-constructed surface of this type followed closely the principles of sound highway construction of the waterbound macadam type, and consequently resulted in a much better mechanical bond between the various sizes of the aggregate and appreciably reduced the amount of watering and rolling required to maintain accurate playing conditions.

There was, however, a further advantage as the interposing of the coarser layer between the foundation and the finer surfacing acted as a bridging coat to prevent the finer material working down into the interstices of the clinker foundation, with a consequent saving in the amount of annual top-dressing required.

A surface laid in this manner naturally takes more time and material and must increase the cost, but it does ensure the maximum durability whatever may be the class of materials used.

Semi-permanent hard courts. The levelling, drainage, foundation, and edging would be carried out as before described, but it is very desirable to carry through the construction with an adequate cross-fall as before described as it will be difficult to maintain porosity indefinitely. If local gravel is used for the foundation where it is more readily obtainable than clinker, there is always a possibility it may contain weed seeds and it would be a wise precaution to treat the foundation with a strong solution of weed-killer before surfacing.

The surfacing may consist of hard, well-burnt boiler clinker, or broken limestone, graded to sizes from 1 to 1½ inches. Broken granite and other similar aggregates are sometimes used but their affinity for bitumen is not so dependable.

The aggregate is spread to a depth of not less than 1½ inches and well consolidated by rolling. This layer is then grouted with a quick-breaking bitumen emulsion at the rate of from ¾ gallon to 1 gallon per square yard applied by hand from cans. Every care should be taken to ensure uniform distribution. Immediately after the grouting a layer of aggregate graded from ¼ to ½ inch is spread to a depth of ¾ inch and thoroughly rolled into the previously grouted surface. The second coat is then grouted with bitumen emulsion at the rate of approximately ½ gallon to the square yard and well blinded with crushed material of approved colour, graded ⅛ inch to dust and well rolled to consolidate.

This type of court when efficiently laid gives a well-bound surface requiring no daily watering and rolling and which, if not abused, should last for a number of years. It may, however, be necessary from time to time to augment and redistribute the dusting of grit to maintain a uniform colour and foothold, but the extent to which this may become necessary will depend largely on local tastes.

Permanent non-upkeep hard courts. The levelling, drainage, and other preliminary works would be carried out as before. The surfacing is usually

PLATE 26. *Sea-washed turf marsh. Turves being boxed to uniform thickness*

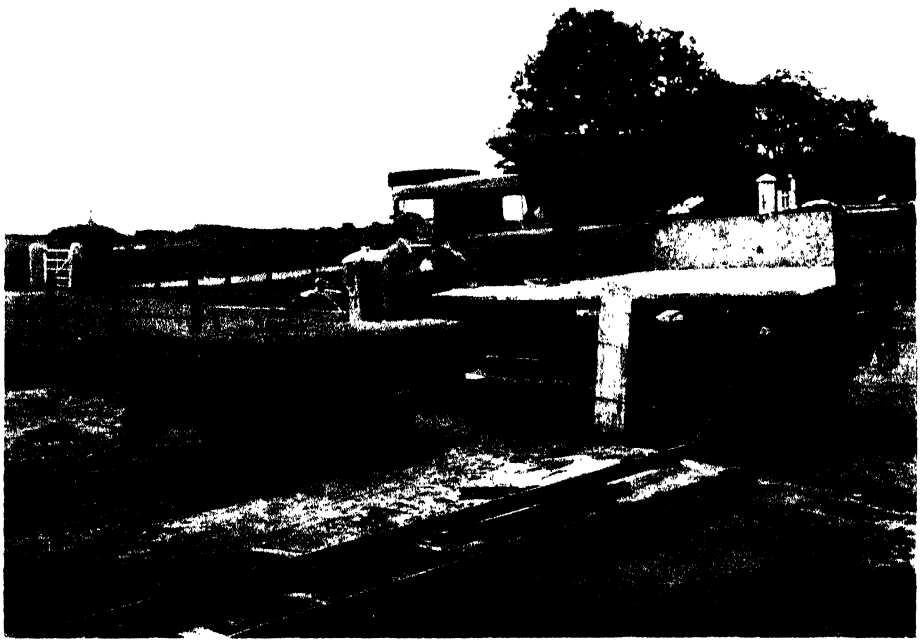


PLATE 27. *Sea-washed turf marsh. Turves transported to roadside by bogies being loaded on to lorry for dispatch*

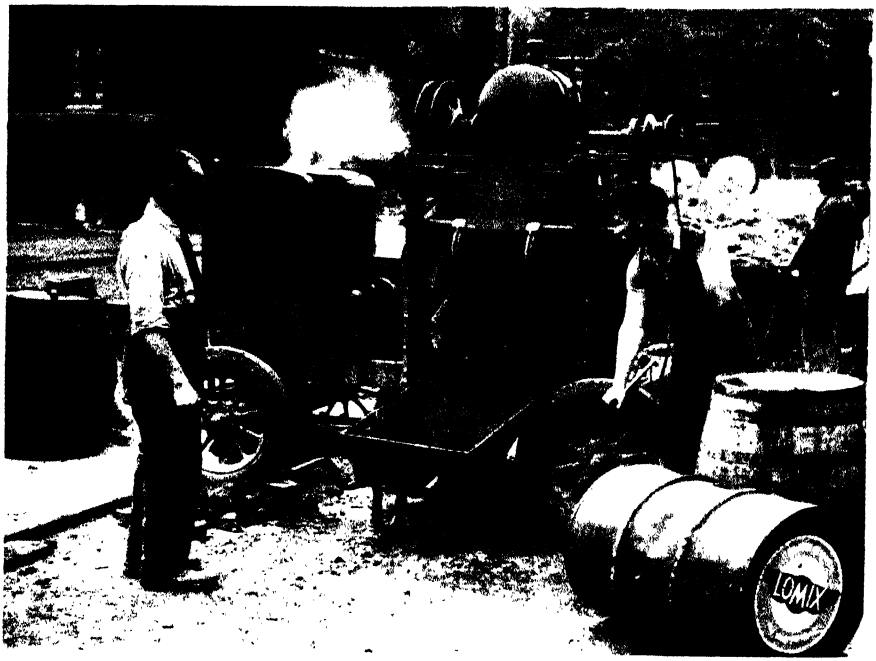


PLATE 28. *Stabilized soil surface. Gauging and mixing materials*

PLATE 29. *Stabilized soil surface. Spreading mixed materials to required thickness*

of two-coat tar or bituminous macadam laid to a total consolidated depth of from 1½ to 2 inches. This may be finished with a porous surface texture or sealed according to the grade of the material used in the upper coating.

As before explained there appears to be little advantage in aiming at porous construction which must sooner or later become sealed through atmospheric impurities being deposited on the surface and working into the interstices.

The best types of surface are obtained where the chippings used in the final coat are of a cubical rather than flat flaky character, as they can be packed with greater mechanical efficiency. Owing to the lighter type of foundation generally adopted for reasons of economy, compaction has to be obtained through the agency of comparatively light-weight rollers in relation to those normally employed on highway surfacings, and accordingly the shape and grading of the aggregate are very important factors in durability. Where too much reliance is placed on the tar or bitumen binders for adequate cohesion frequent respraying may become necessary to prevent extensive disintegration of the surface.

A properly constructed surface of this type, however, should last for many years without attention, but the maximum cross-fall should always be provided to ensure rapid shedding of rainfall.

Colouring of the surface is usually effected by spraying with special paint emulsion after the court has been allowed to weather for four to six weeks to allow any volatile oils in the binders to be driven off. It is possible to use the court during this period of weathering, temporary white lines being marked out on the black surface. The playing-lines are marked out with aluminium paint or white road-line enamel. Apart from re-colouring or re-marking every two or three years no further attention is required normally. If preferred surface may be coloured by dusting and rolling in material of approved colour.

It is important to ensure that no play takes place on any of the foregoing types of hard tennis courts by players improperly shod. None of these surfaces are intended to withstand the severe footwork of players in heeled, leather-soled shoes and only those wearing regulation rubber-soled tennis-shoes without heels should be allowed the use of the courts.

Concrete hard tennis courts. Concrete tennis courts have been constructed with both porous and non-porous surfaces. For the reasons stated above it is hardly worth while endeavouring to achieve a uniformly porous structure which it will be difficult to maintain in such a condition indefinitely. There

is, however, a further risk in porous construction. Should frost set in before water has drained away sufficiently from the interstices, the surface may crumble in places. Porous concrete construction cannot be recommended for use outdoors in this country.

In constructing concrete courts special precautions should be taken in levelling and draining of the site to ensure a stable earth formation, as any appreciable movement must affect the bearing of the slabs resulting in unequal settlement at the joints or serious surface cracking with consequent inaccuracy in play. The courts should be given an adequate cross-fall to throw off the rainfall quickly but this cross-gradient should not exceed 1 in 60 if the effect on play is not to be noticed by the average player.

A thoroughly compacted layer of hardcore, gravel, or clinker to a depth of not less than 4 inches should be provided unless where the soil formation is of sand, gravel, or other clean permeable material.

The concrete slab should be laid in two layers, a base course $3\frac{1}{2}$ inches thick and top course $\frac{1}{2}$ inch thick giving a total slab thickness of 4 inches. The bottom-course concrete should be mixed in the proportions 1 cwt. cement, $3\frac{1}{4}$ cubic feet coarse sand (graded $\frac{3}{16}$ inch down), and 5 cubic feet of broken stone, clean gravel, crushed brick, or other approved aggregate (graded from $1\frac{1}{2}$ to $\frac{3}{16}$ inch). All sand and aggregate must be free from clay, loam, or organic matter.

The top course to be composed of 1 cwt. cement to $3\frac{3}{4}$ cubic feet of sand.

In mixing, just sufficient clean water should be used to produce a workable plastic concrete. Sloppy or very wet concrete should not be permitted, and no concreting should be undertaken when the temperature is under 40° F.

The concrete should be laid in alternate bays as shown in Fig. 55, the joints being made to coincide as far as possible with the playing-lines of the court.

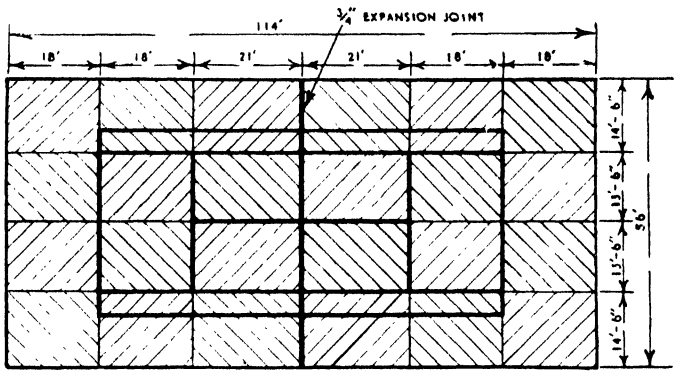
If waterproof paper is available it is better to provide a layer of this on top of the hardcore before placing the concrete, allowing at least a 3-inch lap at all joints in the paper. If no paper is used the hardcore layer should be well wetted immediately before placing the concrete.

Each bay should be completed in one continuous operation and the top course should be laid within half an hour of completion of the lower course to ensure that the whole slab is monolithic in character.

Each concrete section completed should be covered with wet canvas for twenty-four hours following which a covering of sand or earth should be applied and kept continuously wet for at least fourteen days, after which it

may be brushed off. If frost is anticipated, the surface should be protected by covering with hessian, waterproof paper, or other dry material, suitably weighted to prevent disturbance by the wind.

The joints between bays should be vertical butt joints. An expansion joint $\frac{3}{4}$ inch in width to the full depth of the slab should be provided along the net line dividing the court into two halves. This joint may be filled with a mixture of clay and oil, tarred felt, or any of the standard proprietary jointing materials.



NOTE - ALTERNATE BAYS TO BE CONCRETED AND THE INTERVENING BAYS FILLED IN WHEN THOSE FIRST LAID HAVE SET.

FIG. 55. LAYOUT OF CONCRETE TENNIS COURT SHOWING METHOD OF CONCRETING BAYS

The marking-lines can be painted on the surface after it has weathered.

Stop-net surrounds for tennis courts. Fig. 56 shows a typical stop-netting surround for hard or grass tennis courts. The corner and gate pillars are set in concrete as shown, the intermediate standards being usually driven into the ground with earth stay plates to resist deflection from the vertical. In made-up ground or very loose soils it may be necessary to concrete the bases of the intermediate standards also to secure adequate stability, and in very exposed situations outside stays may be necessary to resist bending through wind pressure.

While steel remains in short supply, permits may not be obtainable for the erection of surrounds of this type and, in such cases, excellent temporary surrounds may be arranged by using creosoted larch poles supporting hemp netting. With care these surrounds should give good service for a few years.

Fixing tennis-net posts. The fixing of the tennis-net posts will depend on the type favoured. Where the posts are fixed to sockets permanently set in the ground, the sockets must be provided with adequate concrete foundations.

These should not be less than 1 ft. 6 in. by 1 ft. 6 in. by 2 ft. 6 in. deep to resist the pull of the top cord. Sometimes on clay soils shrinkage of the clay in prolonged drought has affected the bearing of the foundation and posts have been pulled inwards by the tension of the net cord. This cannot happen where the braced type of tennis post is used which distributes the thrust from the top of the post through the struts to a bearing plate resting on the

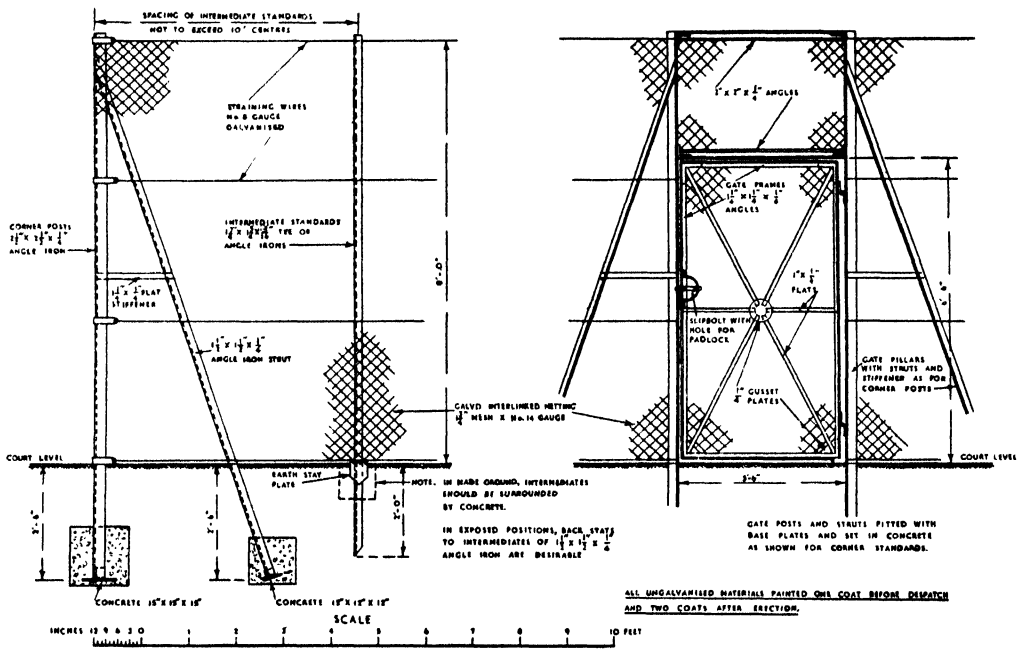


FIG. 56. DETAIL OF TENNIS STOP-NET ENCLOSURE

court surface. These posts are usually anchored by steel holdfast stakes driven into the ground at an angle.

RUNNING TRACKS

The formation of a running track will depend mainly on the finances available for construction and maintenance. It is very unwise to adopt the specification used in the establishment of any particular track known to be highly favoured by athletes without first ascertaining whether such a surface will be suitable to the locational and climatic circumstances under which it is to be constructed and used, and whether similar facilities for maintenance and management can be afforded and arranged. The type of track surface that has stood up well during some continental international sports meeting

held under exceptionally fine weather conditions may prove quite useless over the major part of the year in most parts of the British Isles, not only on account of the vagaries of climate, but also because the arrangements for day-to-day attention and adjustment are seldom practicable in normal circumstances.

Tracks can be constructed of various materials such as certain classes of crushed rocks, broken and crushed bricks, burnt earths, red ash or shale from colliery tips, or boiler clinker and ashes. The last mentioned is probably the most widely used on grounds of economy. The aim should be to provide a true, well-bound, firm surface that will offer a good grip with the minimum surface displacement and which will not lift on the shoes of the runners. If the track is too hard, and impenetrable, sprains and strained muscles may be frequently caused to athletes. If too soft and loose it will be slow and fatiguing.

Some elaborate methods have been practised in an endeavour to ensure spring or resilience to tracks by laying down a layer of faggots or peat before building up the foundation layers, but such practices are much too costly for general adoption on public playing fields and many useful tracks have been constructed without any preparation of this nature. The country is seriously short of athletic facilities, and, if the demands are to be adequately met, it is obvious that the strictest economy will have to be observed both in establishment and maintenance.

The depth and formation of the track will be determined by the existing soil conditions, method of use, materials available, and the most expedient maintenance arrangements. Regarding the method of use, the introduction of starting blocks, if adopted universally by all runners, should allow some reduction in the finer material used in the upper layers of the track, but, as long as trowelling is favoured and allowed, to provide suitable footholds at the start of various events, it will be necessary to ensure a sufficient depth of fine stuff to eliminate any risk of coarse material being brought to the surface by such action to the detriment of textural uniformity at the starting lines. The greater the depth of fine stuff, the greater will be the amount of water required to keep the surface bound, or, where adequate means for watering are impracticable, frequent deliquescent applications will have to be made during dry periods.

Where liberal applications of water or deliquescents cannot be arranged it is advisable to improve the binding qualities of the fine material by incorporating suitable proportions of clay or marl and sand. It will be

obvious, therefore, that to obtain a track surface which will not require constant day-to-day attention and yet will give reasonable satisfaction to the athlete under both wet and dry conditions is not easy to arrange. Too great a proportion of clay or similar binding materials will impede surface drainage, and make for heavy going in wet weather, while to eliminate such binding materials entirely, will necessitate dependence on liberal applications of water or deliquescents, or putting up with a loose dusty surface in dry weather.

Whatever the type of surface favoured it should be clearly understood at the outset that the secret of good track construction lies mainly in the skill displayed in the grading and layering of the materials used so as to ensure a good mechanical bond from the base upward. It is also essential that the edges of the track should be strongly supported to prevent any lateral spread under pressure from rolling or traffic. If attempts are made to economize by spreading material of mixed grade to the required depth and covering with a thin dressing of fine stuff to produce a more uniform surface texture, this will probably result in much of the coarser material being inadequately covered and consequently there might be grave risk of injury to athletes. Furthermore, it will be difficult and laborious to maintain a consistent density of packing if the varying sizes of material are mixed haphazardly in placing.

The track formation to conform to international standards should not have an inclination exceeding 1 in 1,000. For local athletics, however, where the cost of levelling to such a degree is prohibitive, useful tracks could be laid down at any gradient not exceeding 1 in 60, but in such cases it is preferable to arrange the straights transverse to the slope leaving the track gradients to be taken up on the curves.

The track area must be excavated to the required depth as may be dictated by the requirements of the site. For normal medium to heavy soils the usual formation is about 12 inches, which means an excavation depth of 14 inches, as the track should be finished with a suitable edging on either side to prevent lateral movement, and it is recommended in International Rules that the inner border must be 2 inches above the level of the track surface. The outer edge can be finished flush with the track, if preferred.

Fig. 57 shows typical details of construction for a track on a site where the soil is more or less of a retentive character. Any soft spots encountered in the earth formation must be dug out and made firm by filling in with clean, dry hardcore thoroughly compacted. Drains should be provided at each side of

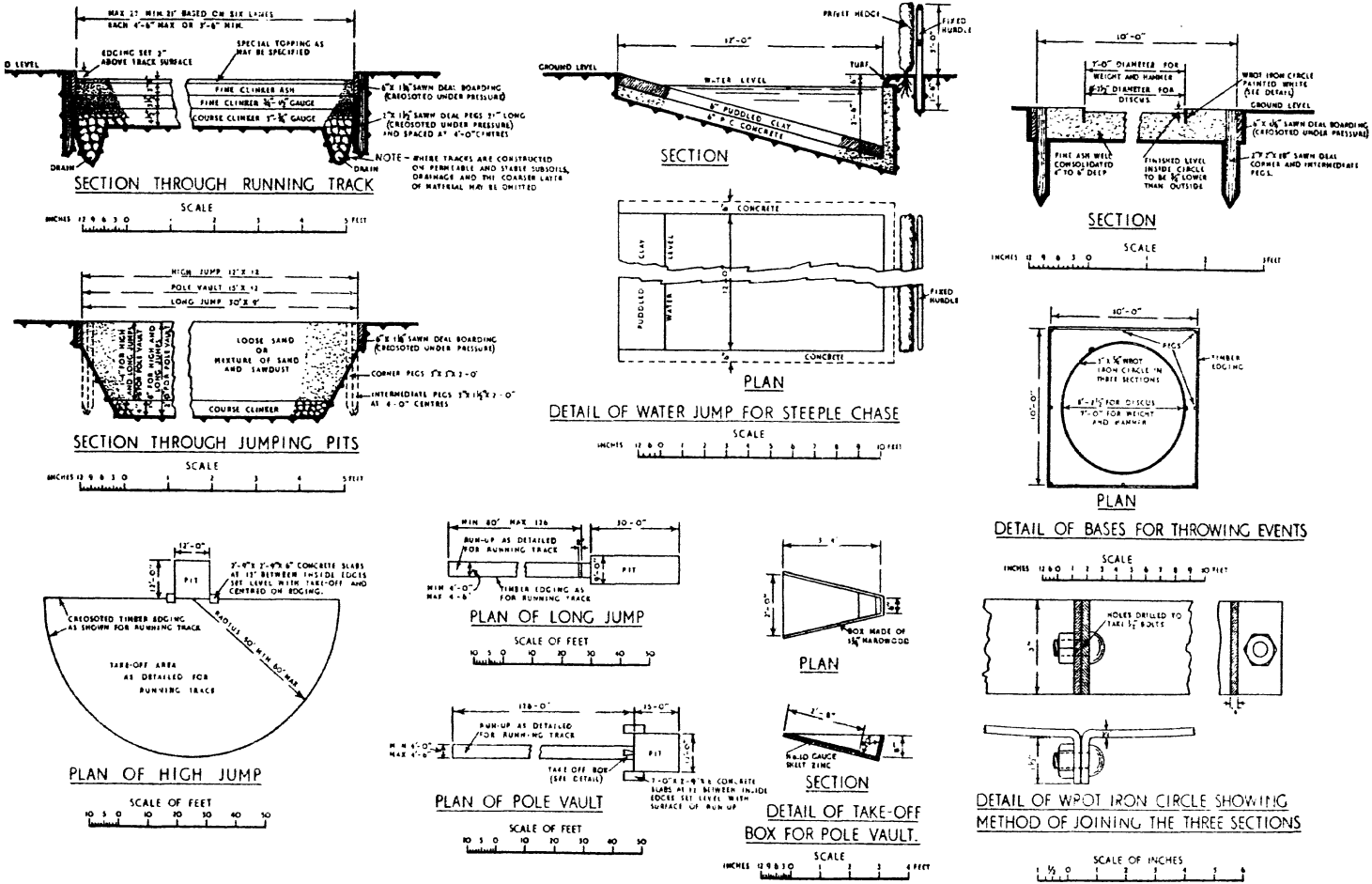


FIG. 57. ATHLETIC STADIUM DETAILS

the track to lead off any water which might accumulate in the foundation before it has time to saturate and affect the stability of the subsoil. These drains should be linked up at convenient points with the main drainage from other parts of the field or led away to other suitable special outfalls.

The edging to the track may be of timber or concrete. Timber edging normally consists of 6 by 1¼ inches sawn deal boarding fixed to 3 by 1¼ inches deal pegs 21 inches long, pointed and driven into the ground at 4 feet centres. All timber must be thoroughly creosoted under pressure and the greatest care should be taken to ensure accurate alignment and levels in fixing.

A more durable and popular form of edging may be obtained by using pre-cast concrete kerbs 6 by 2 inches firmly bedded on, and faced up on the outer side with cement mortar.

After completing the edging, the earth formation as blocked out should be treated with a strong solution of weed-killer before commencing the structure of the track.

A suitable track formation for normal conditions where facilities for watering and day-to-day maintenance are rather limited would be built up somewhat on the following lines:

First a layer of coarse boiler clinker or other approved hard, dry material graded between 3 to ¾-inch-mesh screens. This should be evenly spread over the entire area and watered and rolled to a depth of 4½ inches. Over this a layer of finer clinker graded between ¾ to ½-inch-mesh screens should be spread, watered, and rolled to a consolidated depth of 3½ inches.

For the next layer, finely sifted boiler ash (passing ¼-inch-mesh screens) should be used mixed with similarly graded finely sifted clay or marl and sand. The mixture to be in the proportion of 1 cubic yard of fine ash, 4 cubic feet of clay or marl, and 2½ cubic feet of sand. These should be thoroughly blended, preferably by means of a concrete mixer, with just sufficient water to produce a plastic workable condition. The mixture must on no account be sloppy. The material should then be spread over the previous course to a consolidated depth of 3 inches. Prior to spreading, the surface of the previous layer should be lightly loosened by raking or harrowing to a depth of 1 inch so as to provide a good bond between the courses. When the material has almost dried out it should be rolled to a firm consistency. This surface should again be lightly loosened to a depth of 1 inch and finally surfaced to a depth of 1 inch with fine stuff mixed in the following manner:

One cubic yard of fine ashes, 2 cubic feet of clay, and 1 cubic foot of sand, mixed, placed, and consolidated as before described.

It is impossible to give more than an approximation of the proportions of clay and sand to be incorporated with the upper layers as this will depend on the quality of the ash used. For this reason it is advisable to reserve a quantity of fine ash and fine clay so that suitable adjustment may be made to the track surface in the event of the final condition proving too plastic or too loose.

It will be appreciated that where the subsoil on which the track is built is of a gravelly, stoney, or other hard, dry, coarse-grained, and permeable nature it will not be necessary to provide drainage, and the coarser layers might be eliminated or reduced with a proportionate saving in excavation and material. Where also pre-mixing of the finer materials is not expedient, the fine ash, clay, and sand may be spread in loose layers of appropriate thickness, and thoroughly blended *in situ* by repeated discing, harrowing, raking, watering, brushing, and rolling to obtain the desired uniformity of texture and firmness.

It is important to realize that the rolling of the under layers should only be just sufficient to wedge them firmly into place, and their surfaces should always be loosened slightly before applying further material, so that when the final rolling takes place the pressure may be exerted throughout the entire depth of the structure and a good mechanical bond achieved from base upward.

A 15-cwt. roller will normally be quite adequate for clay-bound clinker tracks. Where, however, no clay is used and tracks are formed entirely of clinker or other material, a 30-cwt. petrol roller may be advisable for the final rolling after thorough saturation of the surface.

Fig. 57 shows details for the construction of the various facilities for field events. The method of construction should be fairly clear from the diagrams. The run-ups to the jumps and bases for the throwing events should be edged and constructed in the manner described for the running track.

CYCLE TRACKS

Fig. 58 shows details for the construction of cycle tracks. The normal methods of construction are either of tar macadam or concrete where durable non-attention surfaces are required. Tracks, of course, may also be formed of cinders somewhat on the lines of the running track specification, but the layer of fine material could be reduced considerably. Watering and rolling of cinder cycle tracks might be eliminated by grouting the clinker with bitumen and dusting over and rolling in fine ash.

A maximum super-elevation at the centre of the curve of 2 ft. 6 in. to

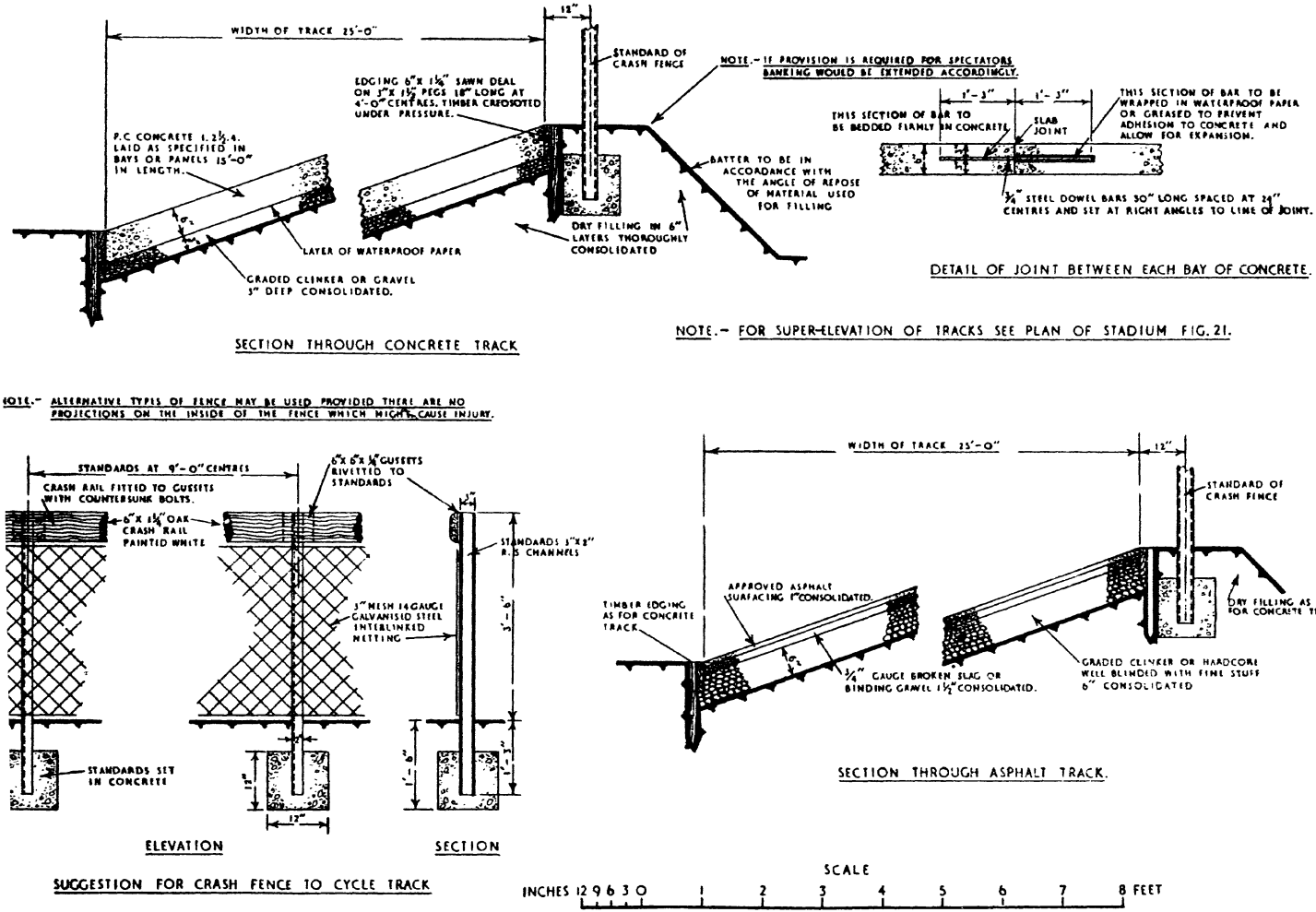


FIG. 58. DETAIL OF CYCLE TRACKS

3 feet diminishing gradually to the ends of the straight, in the proportionate manner indicated on Fig. 21 of the section on space requirements, should be quite satisfactory for cinder cycle tracks.

Detailed methods of construction are given in the section on 'Specification of Playing Facilities'.

ALL-WEATHER DRY-SURFACE PLAYGROUNDS

Where there are confined spaces subject to such continual play that it would be impossible to maintain turf satisfactorily, as in the case of children's playgrounds or games areas for adolescents, it is much more satisfactory to construct these to some form of all-weather surfacing.

The area would require to be levelled and drained as necessary, and, wherever practicable, should be graded to a cross-fall of from 1 in 60 to 1 in 50 to shed the rainfall.

The earth formation should be adequately treated with a strong weed-killer and a suitable hardcore foundation provided. The surfacing may be of crushed rock, binding gravel, or other suitable material to a consolidated depth of not less than 1½ inches.

This type of surface is much cheaper than tar macadam and has a better appearance, but is quite suitable for general romping or organized games. It is apt to become dusty, however, in prolonged dry periods, although this condition can be improved by deliquescent dressings.

It is more profitable, however, to provide a surfacing of tar macadam or concrete to the safety clearance areas around the playground equipment where the traffic is more concentrated and severe. Similarly paved areas of suitable dimensions are useful where it is desired to afford facilities for those popular street pastimes like roller-skating and hop-scotch, and more detailed constructional suggestions are made in the section on 'Specifications'.

An effective concrete or brick edging will prevent any crumbling at the border through lateral movement. If a strong stop-netting surround can be erected, the maximum use may be made of the area by reducing marginal clearances without fear of damage to adjacent property. This stop-net surround should be from 12 to 15 feet high to be effective. A knock-up wall of brick or reinforced concrete, 12 to 15 feet high, at some convenient section of the boundary will be popular for many informal wall games highly favoured by youngsters. The design will, of course, be dependent on the dimensions, class of material available for construction, exposure, nature of subsoil, and other local factors.

CHILDREN'S PLAYGROUND EQUIPMENT

Where swings and other mechanical or gymnastic apparatus are to be erected for the use of children or adolescents, adequate attention must be paid to the erection instructions of the equipment manufacturers. Erection should not be commenced before fully detailed drawings have been received from the suppliers showing the dimensions, spacing, and quality of the concrete foundations required and the order of assembly. Careless alinement and insecure fixing may induce undue strains in the structure, which apart from the risk of accidents is likely to lead to excessive wear and consequently shorten the life of the equipment.

SAND-PITS

Sand-pits, where provided on public playgrounds, should be soundly constructed so that effective measures may be taken to keep the sand in a thoroughly hygienic condition. A site should be chosen which can be well drained and the pit should be enclosed by a suitable wall of brick or concrete to prevent the sand becoming fouled by the falling in of the surrounding earth. The pit may be of any suitable shape to satisfy local tastes or circumstances, but rectangular outlines are normally more economic to construct.

A typical detail is shown in Fig. 59. The site is excavated to a depth of 2 ft. 6 in. and if the soil is of a retentive character and an outlet can be arranged, some land drains should be provided to lead off any water that may collect at the bottom of the pit. The boundary walls are then erected of 9-inch brickwork with bull-nosed brick on edge coping, or, if preferred, 9-inch concrete, and should be carried up to a height of 12 to 15 inches above the level of the surrounding path or paved area. The earth formation should then be covered with a layer of mixed boiler clinker or other suitable hardcore, well blinded and thoroughly consolidated to a depth of 6 inches. Over this hardcore should be laid old cement or stone paving-slabs $2\frac{1}{2}$ to 3 inches thick with open joints to provide drainage.

A concrete moulding platform of suitable size in the centre of the pit is often appreciated by the youngsters. This should not be less than $6 \times 3 \times 3$ ft. in height above the floor of the pit and should be finished with a slightly weathered top. The platform can be simply and solidly formed by building up a core of old bricks, broken concrete, or similar material grouted with cement mortar and cased with Portland cement concrete not less than 4 inches thick. These platforms should not be provided where the pit dimensions are less than 24 by 15 feet.

The sand filling should be applied to a loose depth of 18 inches above the floor of the pit.

PADDLING POOLS

Paddling pools on public playgrounds for everyday use by children must be solidly constructed if waste of water is to be prevented and effective

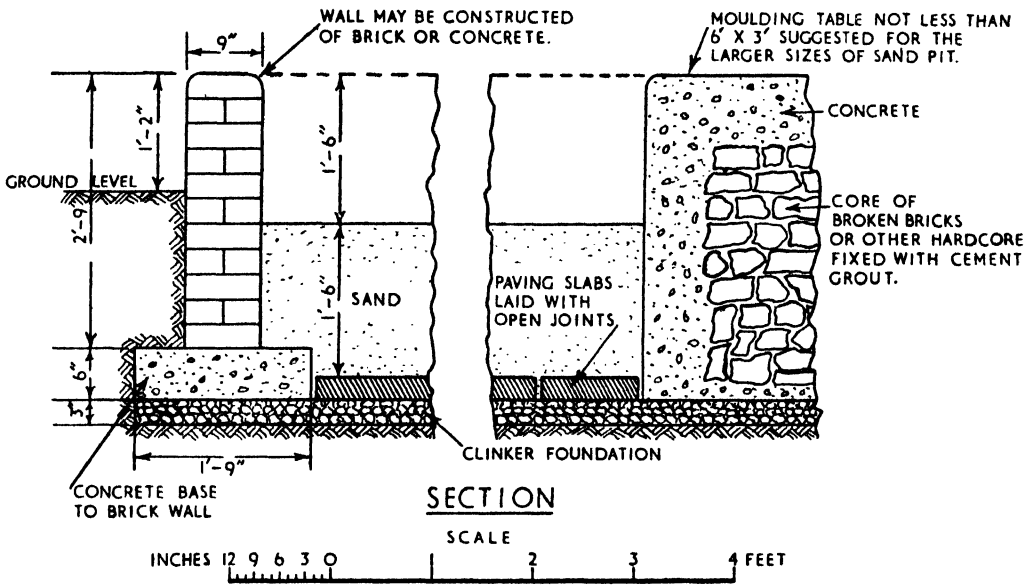


FIG. 59. TYPICAL SAND-PIT DETAILS

means established for periodic cleansing and sterilizing as conditions may demand.

Where arrangements for filling, emptying, and overflow are dependent on public services, these aspects of the design will be determined by the location and capacity of the nearest water-mains and sewers, and the advice of the appropriate authorities should be sought as to the maximum connexions that can be permitted.

Pools may be of any shape but, where cost is a consideration, rectangular pools are more cheaply constructed. Concrete construction is most generally favoured and in large pools the floor and walls should be adequately reinforced with a suitable welded steel-mesh road reinforcement. Due allowance must be made for expansion and contraction of the concrete, and all slab and wall joints must be of watertight construction. Where these details are

efficiently arranged and a dense waterproofed concrete mixture obtained, it should not be necessary to go to the expense of providing puddled clay beneath the pool.

Typical constructional details are shown in Fig. 60. The depth of the water should vary from 7 inches at the sides to 1 ft. 3 in. at the centre. It is not safe to have the maximum depth at one end where young children might inadvertently fall in.

Walls should be built in sections not exceeding 30 feet in length between waterproofed joints. The dimensions of floor panels should not exceed 15 feet, all joints being well supported and waterproofed.

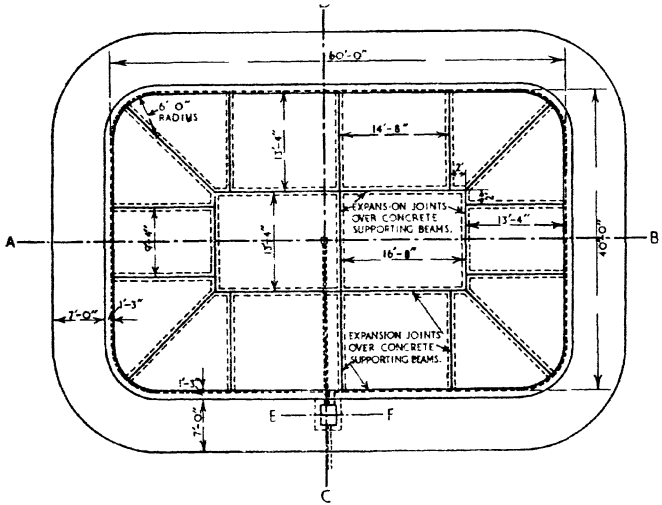
Where, of course, there is a suitable stream of clear water near which the pool may be sited and from which part of the flow may be diverted through the pool and returned again to the stream, watertight construction may not be necessary and a suitable floor of plain concrete to provide a clean and comfortable foothold may be sufficient. In such cases, however, the intake should be controlled by a suitable sluice so that the pool may be emptied for cleaning purposes when required.

GOLF FEATURES: PUTTING GREENS AND APPROACH OR PITCH AND PUTT COURSES

The layout and construction of these popular features call for a specialized knowledge and experience which is seldom appreciated by municipal authorities and others responsible for their provision and maintenance. The specialist must combine a high degree of landscape craftsmanship with a sound knowledge of the game, otherwise the results are likely to be displeasing both to the onlooker and golfer. In addition, carelessness in the layout of the courses may expose players to unnecessary risks, while faulty construction frequently leads to excessive maintenance charges and loss of use in unsettled weather.

Too often the design and construction of golf facilities is entrusted to parks departments whose officials are responsible for the development and upkeep of our parks, gardens, and open spaces. Admirable as their efforts may prove in the various sections of park improvement, administration, and maintenance, their training and experience is mainly concerned with horticulture and landscape gardening and they can hardly be expected to achieve creditable results in the difficult sphere of golf architecture.

There may be special exceptions but taken generally it is not difficult to recognize the hand of the amateur in many of the minor municipal golf



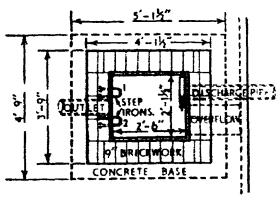
PLAN

SCALE OF FEET

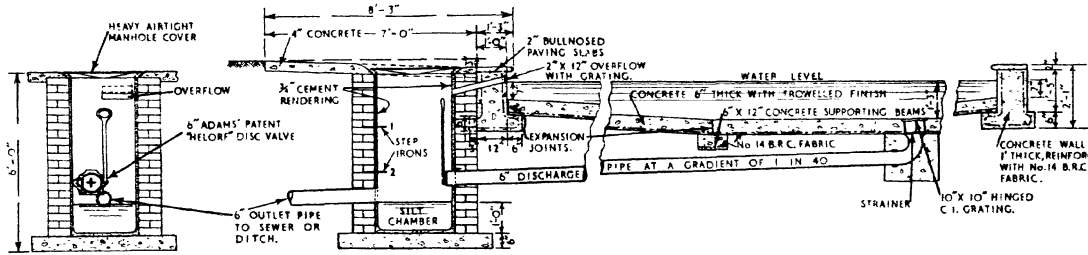
10 5 0 10 20 30 40 50

SECTION ON LINE A–B.

SECTION ON LINE C–D



PLAN



SECTION ON LINE E–F.

SECTION ON LINE C–D

DISCHARGE CHAMBER DETAILS

SCALE

INCHES 12 6 0 1 2 3 4 5 6 7 8 9 10 FEET

FIG. 60. TYPICAL CONSTRUCTIONAL DETAILS FOR A SMALL PADDLING POOL

facilities. Putting courses are frequently only recognizable by the equipment, the layout and playing surface being farcical in the extreme. Areas of existing pasture more suited to a paddock or hayfield are indifferently mown, provided with a few holes, tins, and flags, and the public are invited to—and unfortunately too often do—patronize the 'course' to indulge in the art of putting where only by an act of Providence could a ball be sunk in one stroke. Not content with the impossible nature of the surface provided and ignoring the fact that a putter is not intended to negotiate hazards, great ingenuity is expended in adding to what is termed the 'sporty' nature of the course by the provision of 'bunkers' little bigger than a soap-dish, alternated with miniature embankments interspersed throughout the green with almost mathematical precision. The crowning glory is reached in the 'water feature' provided by an old galvanized bath or pail sunk in the ground and filled with water.

When viewing such a course, one is forced to the conclusion that there must be a considerable number of people who labour under the delusion that golf is merely a game of chance rather than one of skill. The financial returns from these unsatisfactory features may be frequently gratifying to their promoters but they cannot be termed, with the most charitable intentions, golfing facilities. They cannot in any way meet the needs of those who wish to practice putting seriously.

Similar faults are frequently observed in many short courses of the pitch and putt type. Lack of imagination results in a layout providing little variety in approach to the greens and unsightly modelling, disclosing a faint geometrical knowledge on the part of the constructor in the disposition and shaping hazards. The writer has actually seen an approach course where the sand traps were constructed in the wrong direction to the line of play so that the labour expended on their formation seemed purposeless. In another case the hazards consisted of stiff turfed earth mounds similar to newly formed graves interspersed throughout the course without any particular strategic intentions. The whole layout was inefficient and untidy. The tragedy in both these cases was that the courses were situated in densely populated areas and were well patronized, probably because there was no other place available where one might swing a club. Short courses of this type will never induce patrons to take the game seriously.

Any area to be developed as a golf feature must be carefully studied to take advantage in the layout of every natural characteristic. The course should be blended as naturally as possible into the existing contours, offer-

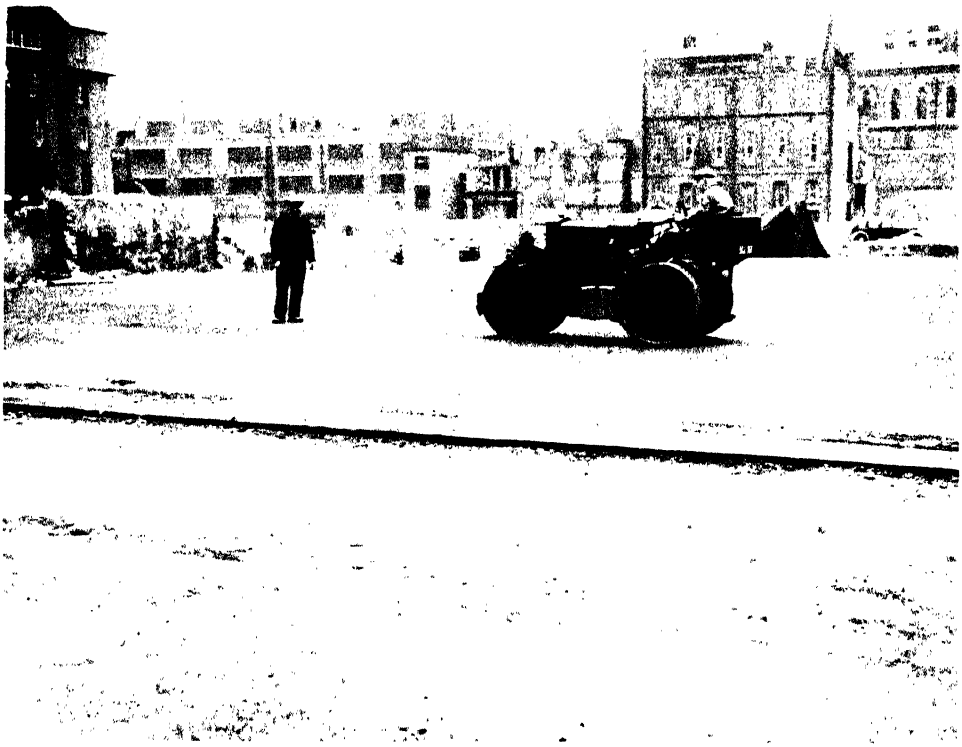


PLATE 30. *Stabilized soil surface. Consolidating stabilized carpet by 2½-ton Motor Roller*

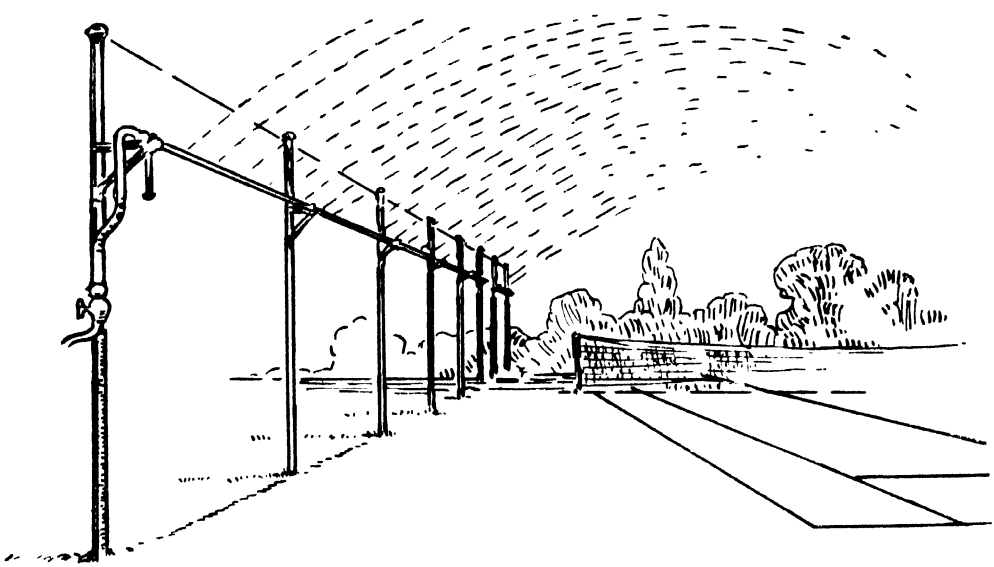


PLATE 31. *Sketch of overhead spray lines fixed to Stop-net Surrounds of Tennis Court*

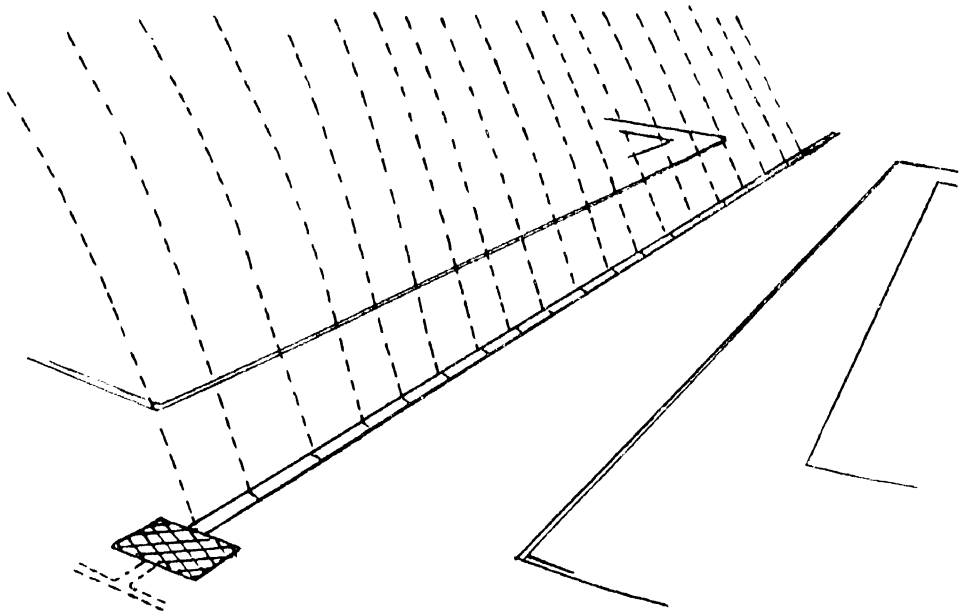


PLATE 32. *Spray lines operating from shallow surface channels*

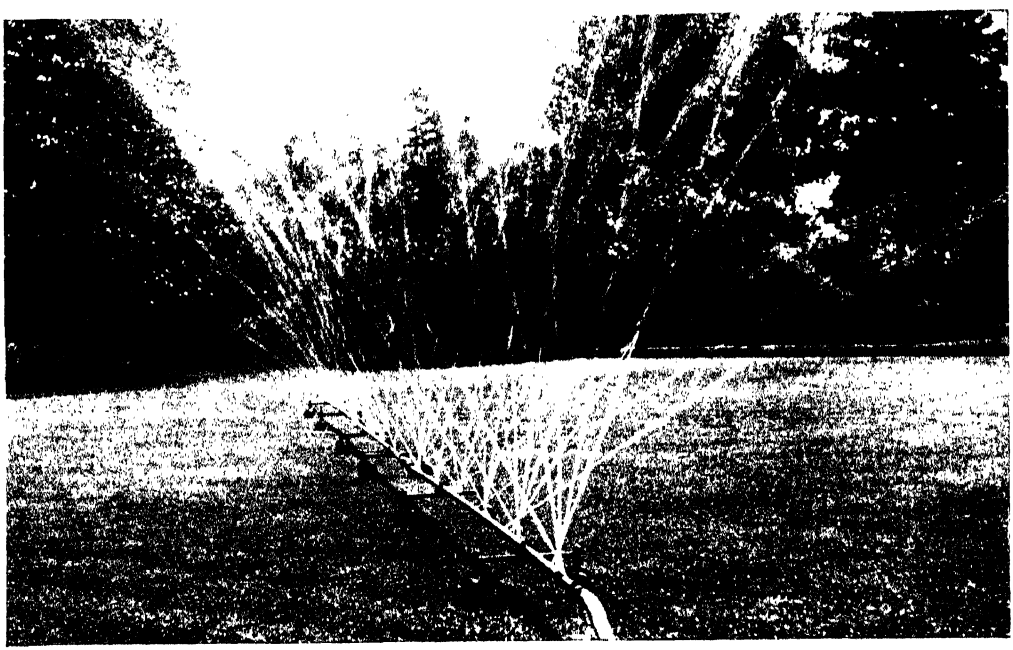


PLATE 33. *A popular type of movable spray line. Adaptable to any irrigation requirement*

ing a challenging approach for the more adventurous and an easier way for the beginner or less proficient. It will be realized, therefore, that a great deal of careful working out is required on the part of the designer and constructor to create a course with the widest appeal.

The construction of the course calls for the solution of several problems arising from the nature of the site in respect of the amount of clearing, if any, contours, geological strata, drainage requirements, chemical and physical treatment of the soil, and the effects of the modelling on play and maintenance operations. If the area is at present pasture-land, the turf should be examined to ascertain whether it can be worked up speedily to a sufficiently fine texture for putting greens. In most cases it will be probably too coarse for greens but quite suitable for the remainder of the course, and accordingly it will be much cheaper and better to cultivate and seed the greens with an appropriate mixture rather than waste time and labour in attempting to put down a turf entirely alien in nature to the purpose in view.

Flat or uniformly graded putting greens lack interest as the only variation offered is in the length of the shots, whereas on a contoured green there is the added attraction of judging the effect of the contours on the run of the ball. The surface should be moulded to easy, graceful rolls avoiding such severe or sudden changes of gradient as might induce a ball to commence rolling before being played. The undulations should be of varying length and direction and the entire area of the green should be available for putting so that the holes may be changed from time to time to distribute the wear on the turf. Too sharp or sudden changes of gradient, apart from restrictions on play, prevent close mowing and rolling and cause the turf to become soft and spongy in places. Generally the undulations should have a width at least fifteen times the rise to ensure uniformity in close mowing and rolling and to avoid rapid drying out on the top of the mounds.

Where greens are constructed on retentive soils the possible effect of surface run-off during rain should be studied and steps taken to prevent ponding in the valleys either by ensuring a continuity of fall throughout their course to a convenient point of discharge on the surrounds of the green or by a suitable arrangement of subsoil drains. Unless there is a sufficient depth of organic soil to ensure that, in contouring, the subsoil is not exposed, or that any section of the green is covered with not less than 4 inches of top-soil, it is best to strip the top-soil from the green to a depth of at least 6 inches before levelling or shaping. The moulding can then be carried out by give-and-take methods and when approved any drainage requirements should be attended

to and the whole formation surface lightly consolidated. The top-soil can then be replaced evenly over the area ready for seeding or turfing.

Contouring of golf greens calls for a practised eye rather than mathematical precision.

Before seeding or turfing any physical or chemical amendments necessary to improve the condition of the soil should be incorporated. Light soils lacking in humus will be benefited by a dressing of granulated peat which will help to bind the soil and make it more retentive of moisture. On heavy soils similar applications of peat increase the porosity and make the soil more workable. An average rate of application would be at the rate of 1 lb. per square yard.

Heavy soils are also benefited by dressings of granulated charcoal which will help to counteract the stickiness and firm the surface. Rate of application—1 lb. per square yard.

All greens before seeding or turfing should be dressed with a high-grade grass-land fertilizer at the rate of 2 oz. per square yard. All dressings should be well raked into the soil.

Seeding or turfing of the greens would be carried out in a similar manner to that described for bowling greens except that in turfing there is no necessity to lay the turves in diagonal courses as suggested for rink bowls.

Hazards have no legitimate place on a putting green.

In the pitch and putt courses there is the approach shot to the green and the holing-out once the green is reached. Hazards in the form of grass mounds, hollows, or sand traps are therefore advisable to orient the greens from the tee, to give character and direction to the approach shot, and to trap badly placed shots from the tee in the interests of play on adjacent greens and fairways. The dimensions of these hazards must be appropriate to their location and purpose. In their formation natural effects should be aimed at and it should not be necessary to state that it is hardly fair to trap a ball and allow the player insufficient room for a recovery stroke. Such faults, however, frequently mark the work of amateur constructors.

To avoid unnecessary limitations of play during inclement weather subsoil drainage of greens, hollows, and traps where courses are constructed over retentive strata must be adequately arranged.

Variety is the essence of golf and should be evidenced in the placing of tees, method of approach to holes, and the shaping and contouring of greens and fairways. Otherwise the course will not realize a fraction of the thrill of golf. A succession of flat uninteresting greens varying little save in length of

approach makes a monotonous round which will only be tolerated where there is no alternative.

Beauty is an important factor, and any natural charm pertaining to the existing topography should be conserved as far as practicable. It is worth while facing a little extra trouble and expense with the layout to this end. The strong appeal of many famous golf-courses is due in no small measure to their peculiar natural characteristics. Trees and woodlands, however, should never be used as hazards to be carried but, in the rough between fairways, they can considerably enhance the beauty of the course. It is surprising what a delightful change can be wrought in an otherwise characterless terrain by plantations of gorse or heather in irregular clumps. In municipal courses, however, the lost ball nuisance must be reduced to a minimum and accordingly such planting should be kept well away from the lines of play.

On approach courses the excessive provision of hazards to be surmounted through the course is not advisable. Traps and mounds should be featured in the vicinity of the green to accentuate its visibility and formation from the tee and the degree of emphasis should be in accordance with its location and character in relation to the general layout of the course. Where, however, as a result of natural contours a faulty or badly placed stroke may roll advantageously towards the green, or be diverted on to adjoining fairways some form of check should be introduced, but restraint must be exercised as the more the area is broken up the greater will be the disturbance to the continuity of routine maintenance.

Greens should be varied in outline and formation as far as their situations permit. They may be saucer-shaped, undulating, plateau, or double-decked but there should be ample scope for varying the position of the hole should the need arise. It is an advantage also if in modelling special care is taken with the fairway immediately adjacent to the green, so that should it be deemed advisable to rest a green for renovation purposes, a temporary green may be arranged on this part of the fairway.

On well-patronized short courses it is difficult to keep good turf tees within the limited areas allotted. Tee-mats will effect a considerable economy in space as well as expenditure on maintenance. For the maximum efficiency, however, they should be laid on a firm well-drained base.

It will be appreciated that it is an impossible task to lay down any hard-and-fast rules for the construction of golf courses, short or long, as in no other branch of sport is it more essential to take advantage of every natural

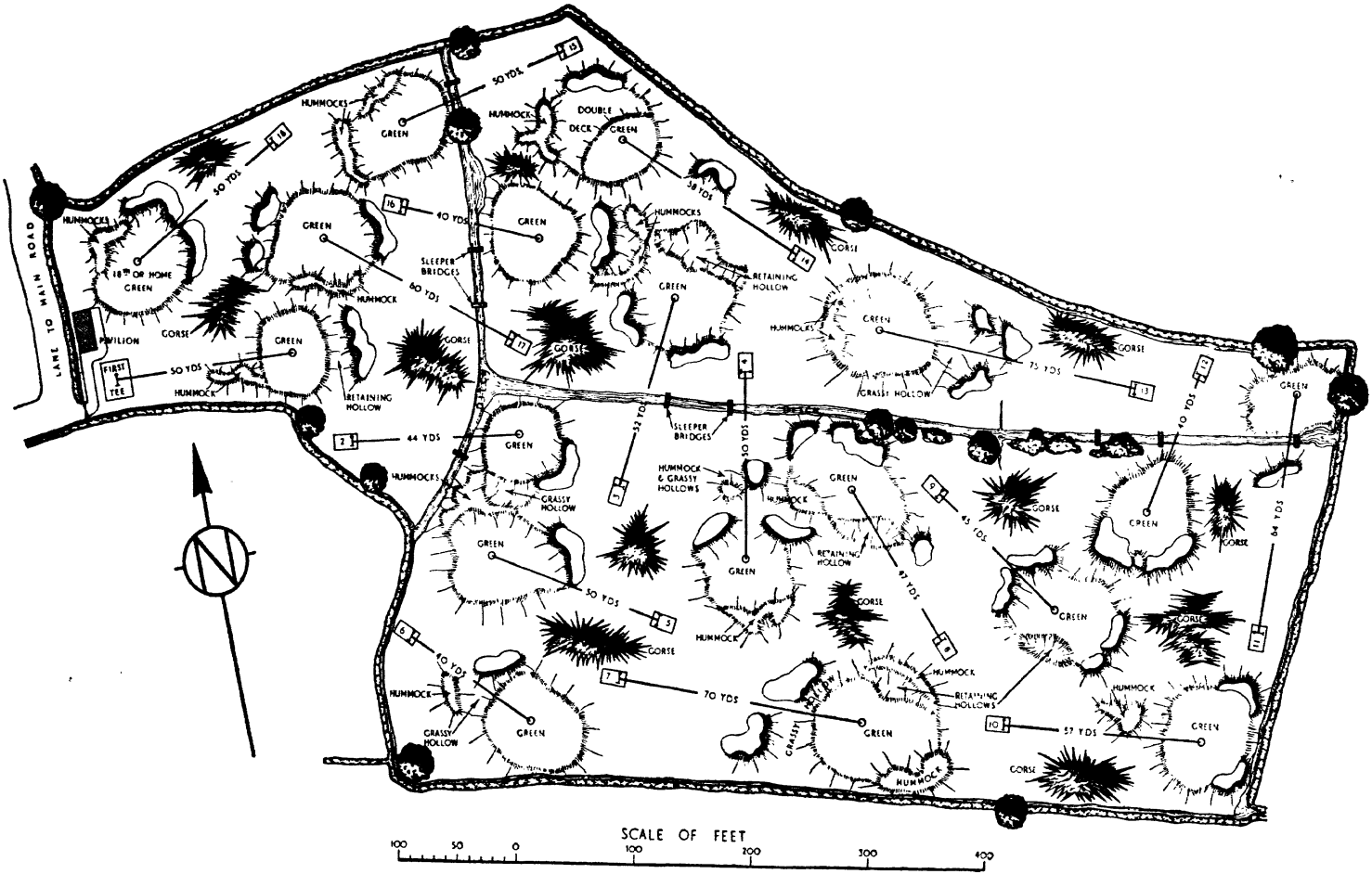


FIG. 61. A 13-ACRE 18-HOLE PITCH AND PUTT GOLF COURSE

characteristic if a really attractive round is to be developed at the minimum cost. The best advice that can be given is to consult an experienced golf architect or constructor when any real golf feature is desired as distinct from a freak side-show appealing only to the frivolous and uninitiated.

Fig. 61 shows an attractive layout for an 18-hole pitch and putt course on a site of 13 acres broken up by watercourses into three sections.

CAR PARKS, ENTRANCE DRIVES, FOOTPATHS

These sports fields amenities so essential to the comfort and convenience of the ground staff and public alike frequently suffer through faulty construction arising from false ideas of economy or sheer indifference to their functional importance. Unless soundly constructed they rapidly deteriorate and become practically useless under those climatic conditions when they should be most appreciated.

The principal faults usually arise from unstable earth formations, inadequate foundations, and poor quality surfaces. In the interests of reduced initial expenditure little or no provision is made by means of subsoil drains to ensure a firm dry base; foundations are often loosely thrown down to the required depth without any attempt at gauging and layering the material which is often too soft and fine; kerbing or edging to contain the structure and resist lateral spread under traffic is considered an unnecessary expense; surfacing materials where provided are usually of the cheapest local gravel obtainable and seldom is a sufficient camber given to shed the rainfall effectively. It is not surprising, therefore, that potholes and waterlogged conditions rapidly develop and pedestrians find it more pleasant and cleaner to walk on the adjacent turf.

In few public sports fields will there be any need to exceed a width of 15 to 20 feet for the main access roads, or 10 feet for the subsidiary footpaths. Where, therefore, these have to be constructed on retentive soils, a 4 to 6-inch porous filled subsoil drain laid along each side of the earth formation will do much to improve the stability of the sub-base. These drains may be linked up at intervals with the general subsoil drains at convenient points or connected to suitably placed sumps. The earth formation should be shaped to a camber with a rise at the crown not less than $\frac{1}{40}$ of the width of the roadway and this camber should be maintained throughout the structure. It is a wise precaution to treat the earth formation with a strong weed-killer before proceeding with the foundation.

All roads, footpaths, and paved areas should be supported at the edges by

means of a suitable concrete edge or kerb, bedded and jointed in cement mortar and set to finish flush with the paved surface. Where turf adjoins any roadway, footpath, or paved area the edge of the turf should show at least 1 inch above the paving so that mechanical mowing and rolling may not be impeded.

Foundations should be of good clean hardcore, well-burnt clinker, broken brick, concrete, or stone, gauged from 3 to 1 inches in size and spread uniformly over the area with the interstices well packed and the whole blinded to a smooth finish with fine material (passing $\frac{3}{4}$-inch mesh). The total consolidated depth should not be less than 6 inches for roadways subject to light vehicular traffic, or not less than $4\frac{1}{2}$ inches for public footpaths. Consolidation in the case of light traffic areas should be effected by motor rollers of not less than 30 cwt. weight. For footpaths the weight of the roller should be about 15 cwt.

Surfacings of two-coat tar or tar-bitumen macadam are more durable and economic in the long run than gravel or waterbound surfaces. The consolidated thickness of surfaces should not be less than $2\frac{1}{2}$ inches for light traffic roads or $1\frac{1}{2}$ inches for footpaths and where carried out in tar macadam the work should be in accordance with British Standard Specification No. 1242 'Tar macadam, tar paving for footpaths, playgrounds, etc.'.

Where on grounds of economy gravel or waterbound surfaces have to be adopted they should be sealed by spraying with tar or bitumen and gritting before the final rolling.

Car-park areas attached to playing fields are far too frequently left in an unfinished state. Sometimes little attempt is made to level and drain the site satisfactorily and the parking space, if constructed at all, merely consists of a layer of roughly thrown mixed hardcore or ashes, insufficiently packed or blinded, and without any consolidation except what is effected by the action of traffic. Consequently potholes are rapidly developed which become flooded in wet weather, or in dry weather the surface is loose and dusty. The area is apt to become weed-infested and a source of infection to other parts of the ground.

Such methods of economy in construction may be permissible as a very temporary expedient, but where parking arrangements are to be a permanent feature they ought to be constructed to the minimum requirements suggested for entrance roads with adequate support round the edges to prevent crumbling. Car parks should be laid to gradients of approximately 1 in 60 wherever practicable.

Where the area is appreciable and the initial costs must be kept down a reasonable economy may be accomplished by providing a soundly laid foundation, well blinded with fine stuff and consolidated, and finally tar-sprayed and gritted. This will normally give a serviceable area for two to three years pending the provision of a more durable surface later.

BITUMEN–CEMENT STABILIZED SOIL SURFACES

Car parks, playgrounds, and footpaths have been successfully constructed of soils stabilized by the bitumen–cement process.

A well-balanced combination of a stable bitumen emulsion, Portland cement, and soil will produce a stabilized material of high bearing strength with a certain degree of plasticity and adequate resistance to immersion in water.

An emulsion with a very slow rate of break is mixed with the soil and fine aggregates, the water in the emulsion acting as a carrier and allowing the bitumen to penetrate to the very fine particles. The slow rate of break allows time for large area mixing without premature coagulations and balling up of the bitumen.

The mixing of the emulsion and the soil may be carried out either by penetration (mix-in-place) methods or alternatively by premixing in suitable mechanical concrete-mixers. The cement is added after the soil and emulsion have been thoroughly mixed to stimulate the dehydration process and speed the set of the mixture.

In most cases it is advisable to incorporate with the mixture a quantity of weed-killer according to the type of soil being treated.

For footpaths, car parks, or playgrounds up to 4,000 superficial yards in extent it will be probably more expedient to use a concrete-mixer and spread the mixed material as a carpet. For areas from 4,000 to 20,000 superficial yards the penetration method may be more economical, the mixing being effected by tractor-drawn spring tooth or spike harrows, rotary cultivators, or similar agricultural implements as may be most expedient. For the penetration or mix-in-place process the soil must first be scarified to the required depth and finished to correct levels or gradients by means of a blade grader, road drag, or other suitable means, after which the area must be moistened with water if necessary to bring the soil approximately to the plastic limit.

The emulsion is then sprayed on to the soil by pressure tanks or hand sprayers and thoroughly mixed in by harrows or other approved means.

This process is repeated until the specified quantity of bitumen has been added. A period of twenty-four hours or more according to weather conditions is allowed for drying out and the cement is then spread at the specified rate and thoroughly worked in by harrows or similar means.

When the treated area has dried out to slightly below the plastic limit compaction should be commenced using a sheepsfoot roller. This rolling is continued until the feet of the roller ride well on the surface, when final consolidation is effected by means of a 5 to 10-ton road roller.

To provide the maximum resistance to wear a surface dressing of suitably graded chippings and bitumen should be applied to a suitable depth in the usual manner. This wearing surface should not be applied before the stabilized base has thoroughly dried out.

For very large areas there are special travelling mechanical mixers for economically mixing and spreading of the material.

Where the premix method is adopted the materials should be mixed with the emulsion in a concrete-mixer preferably of the paddle type. Additional water may be added to ensure dispersion of the emulsion throughout the material, but the quantity must be kept to a minimum.

When the soil and emulsion have been well mixed the proper quantity of cement is added and mixed until the mass is of an even colour. The whole mixing process should be accomplished in two to three minutes.

The mixture is then spread and raked evenly to the required depths and after one to two hours may be partially consolidated by hand rolling. Final rolling should take place after twenty-four hours if weather conditions are suitable and the rolling should be carried out by a power roller of not less than $2\frac{1}{2}$ tons.

The surface is left for two to five days to dry out and should then be surface-dressed or provided with a wearing coat of suitable depth.

The quantity of emulsion stabilizers required will vary according to the grading of the soil. It is controlled by the percentage of clay in the soil (200-mesh size and under) which should not exceed 30 to 50 per cent.

Soils with an excess of clay may be treated successfully by adding sand or quarry waste to amend the grading before adding emulsion.

To obtain the best results it is best to entrust the work to specialists who will be able to determine from laboratory tests what amendments are necessary to the soil grading and the most economic proportions of bitumen and cement required for a successful mix.

An interesting playground approximately 1,500 superficial yards in area

was constructed on a bombed site in Holborn with stabilized soil under the direction of the Borough Engineer and Surveyor, Mr. K. C. Iliffe, Ll.B., A.M.I.C.E.

The site was irregular and for levelling, filling had to be provided to depths varying from 1 foot to 3 ft. 6 in. Filling materials of varying types were used such as brick, concrete, clinker, and vegetable soil. Compaction to required levels was carried out by 2½-ton roller.

The soil used for the stabilized carpet was obtained from the barricade and earthworks constructed during the war on one of the public squares of the Borough. It varied considerably in nature, a certain proportion consisting of Hoggin with a fairly high percentage of clay and vegetable soil intermixed. No attempt was made to grade the soil on arrival at the site and it was used as it came in bulk. To achieve a more uniform consistency to the surface soil, however, a quantity of crushed clinker was added during mixing operations.

A 7/5 concrete-mixer was used and the mixture was as follows:

Soil: 14 shovels—68·0 per cent. by weight.
Crushed clinker: 7 shovels—23·0 per cent. by weight.
'Lomix' bitumen emulsion: 2 shovels—6·0 per cent. by weight.
Cement: 1 shovel—3·0 per cent. by weight.

Water was added to ensure the dispersion of the emulsion throughout the soil, the quantity being the minimum to facilitate spreading and rolling. Weed-killer was added to the emulsion prior to mixing.

Soil and clinker were placed in the mixer first and allowed to mix well before adding 'Lomix' bitumen emulsion. After mixing in emulsion cement was added and mixed in thoroughly till the mixture attained an even brown colour.

The mixture was then spread and raked evenly between 3-inch screeds. After one to two hours, when the mixture had darkened considerably due to the breaking of the emulsion, partial consolidation was effected by a 10-cwt. hand roller. Final consolidation by 2½-ton roller took place within twenty-four hours of the laying, depending on weather conditions.

The stabilized soil carpet was then allowed to dry out for three to ten days according to the weather and was then surface-dressed with 'Colfix' emulsion at 6 square yards per gallon and sanded over.

The final carpet was consolidated to 2 inches.

Plate 28 shows materials being mixed in the concrete-mixer.

Plate 29 spreading and raking to 3-inch screeds.

Plate 30 compaction of stabilized carpet by 2½-ton roller.

The author acknowledges with thanks the assistance of Messrs. British Bitumen Emulsions, Ltd., Slough, Buckinghamshire, for supplying the matter on which these notes are based and permitting the use of the photographs.

WATER-SUPPLY

All fine turf areas of sports fields—cricket tables, bowling greens, tennis lawns, and putting greens—should be provided with adequate facilities for rapid watering should the need arise. Dry surfaces, especially of the water-bound type in use as tennis courts, net-ball courts, play areas, and running tracks will also require efficient watering arrangements to allay dust and prevent the surface cutting up too severely. Water is often desirable also for cleansing more permanent surfaces by pressure hosing from time to time.

It is not practicable to outline any water-supply system which would be generally applicable to all playing-fields schemes. The finances available for the installation and the nature of the supply must be the determining factors in deciding what can best be arranged. Where the supply is to be taken from the public mains the capacity of the system will be limited by the pressure and the maximum meter connexion which the authorities will allow. If, however, an independent supply can be economically arranged by pumping from a stream or convenient well greater latitude may be possible both in relation to the diameter and quality of the supply pipes and the working pressures. Adequate supplies from the public mains in certain districts for the watering of sports facilities may not be permitted or, where allowed, the use of the service is frequently banned during prolonged periods of drought, just when the need is greatest. In such cases the most serious consideration should be given to the possibility of providing some underground storage tanks, fed from the subsoil drains or by the run-off from roofs of buildings, which will provide a limited reserve for use in extreme emergency.

Once the source of supply is known the general scheme should be entrusted to an experienced firm of water engineers who will be able to determine the most efficient and economic method of distribution.

There are various methods of overhead irrigation in common use on sports fields, and in the writer's opinion they are much to be preferred to underground arrangements for flooding playing surfaces which it is claimed reduces loss by evaporation. Any faults in watering equipment above ground

can be instantly detected and easily rectified. Underground defects, however, may pass undetected for some time and correction may entail much trouble and suspension of play.

Overhead sprinklers and spray lines have reached a high degree of efficiency where properly adjusted to the working pressures available and, used in the proper circumstances, are as near an approach to natural rainfall as can be obtained. There is always a possibility of soil washing or scouring from badly adjusted or otherwise defective underground distributors which may sooner or later upset the stability if not the growth of the playing surface.

It must be realized also that rainfall not only wets the soil but cleanses the foliage as well and any artificial watering system which ignores this fact only partially fulfills its functions. An underground system would be no use whatever in assisting the penetration of fertilizer and other dressings.

While there are sprinklers designed to operate on very low pressures (6 lb. per square inch), the most serviceable types require water-pressures of from 20 lb. to 50 lb. per square inch, and the normal size hose for the average revolving sprinkler is $\frac{3}{4}$-inch diameter. There should be, therefore, a $\frac{3}{4}$-inch hydrant fixed at a convenient point, for each facility to be fed by a sprinkler, to which the supply hose can be attached. Where a movable sprinkler is employed about 120 feet of hose would be ample to cover a single tennis court, bowling green, or cricket square of average dimensions, but where the area is large, as in the case of a range of tennis courts in one enclosure, the number of hydrants will have to be increased to suit the number of sprinklers and lengths of hose available.

The watering of tennis courts, running tracks, and similar areas requiring quick coverage with the minimum of attention can be normally efficiently accomplished by fixed oscillating spray lines attached to the fencing surrounds. An illustration of fixed spray lines attached to the uprights of tennis fencing surrounds is shown in the sketch Plate 31. Plate 32 indicates how spray lines between two or more courts in the same enclosure are arranged in shallow channels let into the surface of the court and covered with steel plates slotted to allow the jets to come through. In strong adverse winds, however, the throw of the water is restricted on those lines spraying into the wind and in such conditions uniform wetting may be difficult to obtain. There are, however, portable spray lines mounted on ball carriages designed to cover a width up to 50 feet and any length up to 120 feet with an evenly distributed spray and these can, with a few changes of position, water any

bowling green, tennis court, or similar grass area in a reasonably short time. An example of this type is shown in Plate 33. These illustrations are taken by permission from the catalogues of Messrs. British Overhead Irrigation, Ltd.

For longer lengths up to 100 yards, oscillating spray lines are available. These are set up on tubular supports pressed into the ground and can be moved and re-erected in a fresh position in a few minutes. The spraying width is from 50 to 60 feet, but much depends on the type of jet nozzle, the volume and the pressure of water.

Where spray lines are used a larger supply pipe-line will be necessary as these normally require from 1 to 1½ inches diameter according to the type.

The underground supply pipe-lines to the various hydrants will have to be of adequate capacity to maintain the working pressure necessary to the type of equipment in use, and where the supply is taken from the public mains the quality of pipes and fittings will have to conform to the regulations laid down by the Water Board, or other authority concerned. All supply pipes should be laid at a depth of 2 ft. 6 in. below ground and it is advisable to provide drain-off cocks at appropriate points in the system so that when the supply is turned off in winter, the water may be drained off to avoid any damage by frost.

Wherever possible the supply pipes underground should be laid in the margins of pitches, greens, or courts, rather than actually under any playing area, so that in the event of opening up for repairs any serious interruption to play may be avoided.

FENCING

Where playing fields have to be enclosed against trespass or unnecessary traffic by pedestrians, the type of fence must be decided by local tastes and resources. Whatever may be the class of fence adopted, it should be of adequate strength, firmly fixed, and of pleasing design.

In pre-war days the most popular, permanent boundary fences were of the wrought iron unclimbable or palisading types where a close screen was not desired. It will probably be many years before fences of this type are available for general use, and the choice is likely to be restricted to chain link netting on concrete posts, or various types of concrete fencing.

Chespale fencing cannot be recommended except for temporary enclosures pending the development of a suitable hedge or the later erection of a more

solid type of fence. Close-boarded wooden fences entail heavy maintenance costs and have a tendency to warp and become unsightly. Where privacy is essential the most desirable, easily erected type of boundary fence is of pre-cast concrete posts and panels. These can be obtained in varying designs and to any normal heights desired.

Architectural advice should be taken as to the most appropriate type of fence.

Fences of the hurdle, post and rail, or post and wire types are of little use as they are easily surmounted by young and active people. Barbed wire should not be used against a public footpath or highway where there is risk of damage to the persons, wearing apparel, or property of passers-by which may induce claims for compensation.

No boundary fence should be less than 6 feet in height.

Gates opening on to a traffic roadway should be so sited and arranged as to give a clear view of the oncoming traffic before leaving the field, and their position should be clearly indicated to drivers of vehicles and others using the highway. In the interests of road safety, concealed entrances must be avoided at all costs.

V

MANAGEMENT AND MAINTENANCE OF PLAYING FIELDS

It is much easier to convince people of the necessity of good planning and construction in playing-field development than to awaken them to their responsibilities for management and maintenance. Yet, however simple or complex the character of any recreational project, the importance of maintenance must be a primary consideration. If the problems of efficient upkeep and their implications are not fully appreciated and provided for at the outset, there will be grave risk of the capital expenditure on construction being partially or entirely frittered away in the course of a season or two.

What is maintenance? Maintenance as applied to playing fields is so often misunderstood or limited in extent that it may not be out of place here to state the following dictionary definition: 'the act of maintaining, sustenance; support; continuance; defence; means of support'.

Too many are content to confine their maintenance activities to those somewhat restricted tidying operations of cutting and rolling. Yet, if the analogy may be pardoned, few human beings would be so unintelligent as to imagine they could maintain themselves by satisfying their tonsorial requirements while neglecting all other essentials to health and happiness.

Consider for a moment the various aspects of maintenance as suggested by the definition quoted. 'Sustenance' surely implies the provision of all material requirements for proper nutrition. 'Support' calls to mind the soil in which the grass is rooted and upheld, and the necessity to ensure that its physical and chemical condition is conducive to healthy growth. 'Continuance' envisages those operations of reparation and renovation essential to permanence. 'Defence' suggests the measures which must be taken against attacks by disease and insect pests in addition to the prevention of malicious damage and abuse. Finally, 'means of support' might remind us of the importance of making adequate financial provision to meet all possible demands of maintenance.

It should now be realized that the problem has many ramifications which require constant study, correlation, and co-ordination in the interests of efficiency and economy. The subject is vast and embraces so many variable and indeterminable factors, arising from local, climatic, and other natural

influences, that it would be quite impossible to deal fully with it in a work of this nature. An outline of the principal aspects of good maintenance and their functional attainment in relation to playing facilities is all that can be essayed here.

Organization. Of first importance is the constitution of a proper and effective committee of management with full powers to determine the times and conditions for use of the facilities provided. They would also have to employ an adequate and experienced ground staff suitably equipped with modern labour-saving implements and accessories as far as the available finances will permit, and arrange supplies of fertilizers, seeds, turf, and similar commodities when required. The committee must be in constant touch with the groundsman in charge from whom they should receive regular reports on the condition of the various facilities so that prompt and appropriate action may be taken when necessary.

In larger boroughs and urban districts with separate departments for parks and open spaces under experienced and efficient parks superintendents the organization generally operates smoothly and economically, but in the case of smaller communities or unofficial committees it is generally advisable to appoint one member of the committee as Ranger or Supervisor who should be responsible for seeing that any instructions regarding the management or maintenance of the ground are duly attended to by the ground staff. All work on the ground should be under the sole direction of one person. If every member of a committee is permitted to give orders individually, the groundsmen will not know whom to obey and will probably end up by pleasing themselves, and this multiple control will result in chaos rather than system.

Again, in country districts where it is impracticable to retain a regular groundsman and maintenance operations are entrusted to a local farmer or agricultural contractor, it is important to ensure that these functions are performed with reasonable regularity as may be demanded by the surface conditions of the sports facilities concerned, or as may be dictated by climatic circumstances.

Ground staff. It is not practicable to define the amount of labour necessary to maintain a ground of any given acreage. A large acreage devoted solely to field games such as rugby, soccer, cricket, and hockey, where it is economically practicable to employ tractor-drawn or power-driven implements is much more easily dealt with than a smaller field containing a greater variety of recreational facilities such as tennis, bowls, a putting course, and children's playground in addition to the general area for team games. Bowling greens,

cricket squares, grass tennis courts, waterbound hard tennis courts, putting greens, and similar features demand a much greater sequence of intensive maintenance operations, if a reasonable standard is expected, than is normally given to general grass areas used only for football, hockey, cricket outfield, and other organized games or impromptu play.

It obviously follows that where up-to-date equipment cannot be afforded or maintained, ground operations become more laborious and prolonged, and where the facilities are widely dispersed much time is lost in transit of equipment with consequent interruption to the continuity of working arrangements.

Value of voluntary labour. In many of the smaller villages much has been, and still is being done in the maintenance of playing facilities by voluntary labour given by club members using the ground. Voluntary labour, however, can only be relied upon when it is regularly contributed on a properly organized basis strictly in accordance with a prearranged schedule. If individual members of such a labour force are allowed to exercise their own discretion as to when and how their energies are to be expended, then it is useless to place any value on such services. Efficient maintenance demands that the right action should be taken at the right time and any offers of help which are indefinite or spasmodic in character are totally inadequate and should be declined.

Equipment. The maintenance tools and equipment desirable for any particular playing field naturally depend on:

1. The means available for purchase, running costs, repairs, and replacement.
2. The acreage of general grass-land for team and organized games.
3. The number and variety of the other and more specialized recreational facilities.
4. The experience and industry of the ground staff.
5. The proximity or otherwise of adequate water services.
6. The natural characteristics of the field especially as regards soil conditions and surface gradients.
7. The influence of layout arrangements in relation to dispersal and grouping of facilities.
8. The opportunities for hiring heavier types of mechanical implements whose use may be advisable only on special occasions.

It will be evident therefore that only a suggestive outline of suitable implements and equipment can be considered. The best type to meet any particular

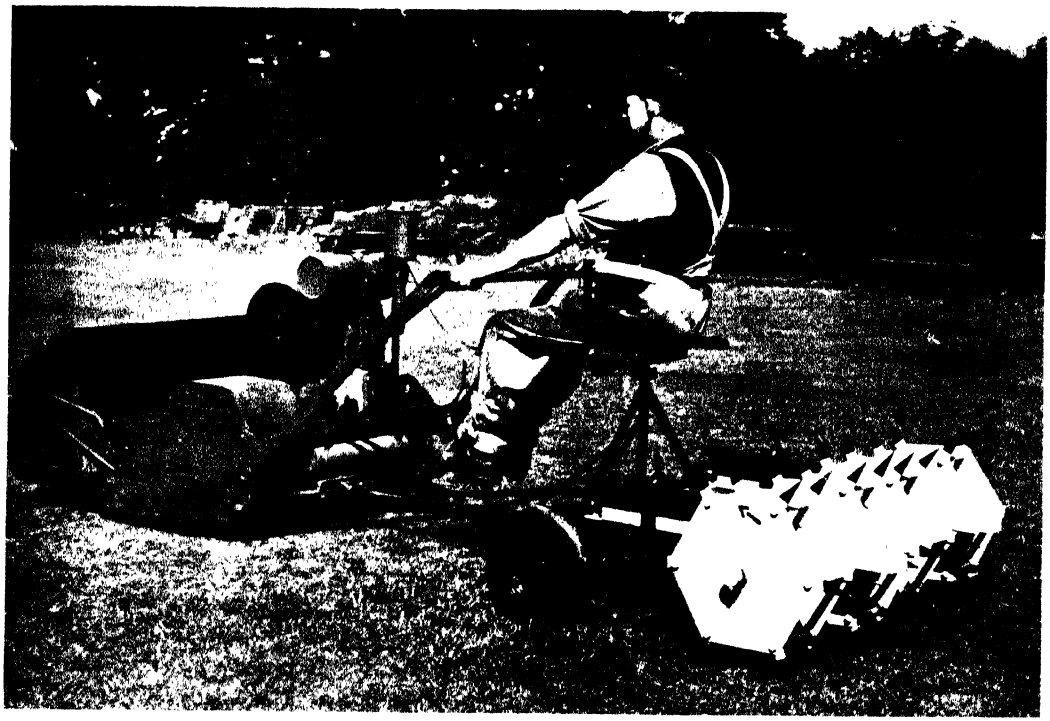


PLATE 34. *Motor-mower towing 'Sisis' Spiking Machine for effective aeration*

PLATE 35. *Motor-mower towing 'Sisis' Rake Scarifier and Brush*

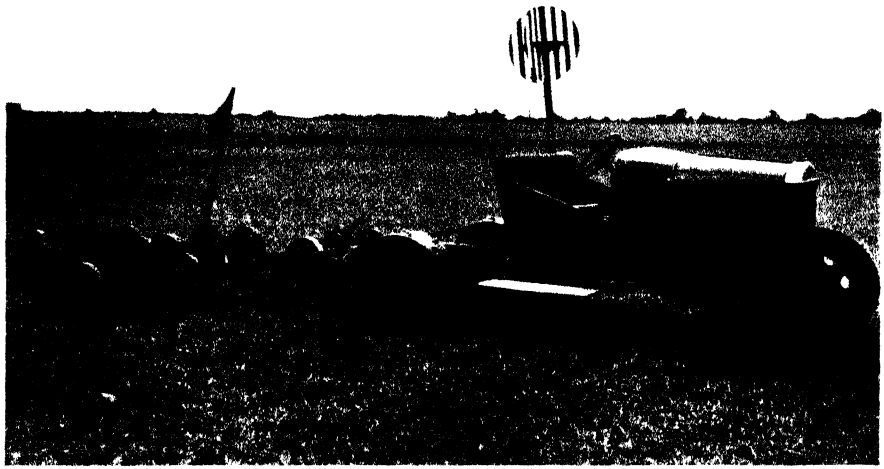


PLATE 36. *Sports Ground Tractor with quintuple gang mowers on an aerodrome*

PLATE 37. *The 'Sisis' Tru-Level Roller*

requirements would have to be determined locally with due regard to the financial resources to hand. It is a tragic fact that in many cases where low upkeep costs are most essential, the necessary equipment cannot be afforded and the standard of maintenance is either lowered to a disturbing degree or upheld only by exhaustive human effort. It is especially hard on residents in smaller isolated villages and townships who, very often to a large extent by their own efforts, have succeeded in establishing outdoor recreational facilities, are forced to shoulder the heavy burdens of maintenance which hardly trouble their urban brethren.

There is evidence, however, of an awakening in the counties and rural districts to the importance of the problem and schemes are being worked out by progressive authorities for the establishment of mobile maintenance units capable of dealing rapidly with the routine cutting and rolling of all playing fields in their areas. Local education authorities will in any case have to face up to this problem of maintenance in connexion with their responsibilities for school playing fields under the Education Act, and to save duplication of plant and manual labour will have to set up such an organization with a sufficient number of branch depots and transport as may be necessary to cover the area effectively. At very little extra cost it should be possible to include in the scheme all other public playing fields which cannot be economically operated by the communities themselves on account of low rateable values. After all, with the increasing dangers from fast-moving traffic on our country roads, no less than in city streets, surely there is an obligation on the part of county councils and rural district councils to ensure that all their residents, whether domiciled in compact townships or isolated villages, shall have ample and well-maintained facilities for indulging in games or other forms of outdoor physical recreation in reasonable safety.

In setting up such maintenance services, too narrow a view must not be taken in planning the scope of operations. As already explained, mechanical mowing and rolling require to be augmented by many other activities if sports fields are to be upheld in a satisfactory condition for play. While there are many ingenious labour-saving machines to perform these additional functions, a complete range would be probably beyond the resources of any single playing field maintenance organization.

The following brief outline of equipment and machines available should be considered and a suitable selection made in accordance with the type of facilities to be maintained and the amount of money that can be raised for their acquisition and operation.

Mowing-machines. Smaller areas of grassland not exceeding 10 acres in extent can be quite economically dealt with by motor mowers. The size would be in accordance with the area to be cut and the time that can be allowed for cutting. Most popular sizes are 24-inch, 30-inch, and 36-inch cut, and the approximate areas cut per hour are:

Cutting width 24 inches—from $\frac{1}{2}$ to $\frac{3}{4}$ acre per hour.
,, 30 inches—from $\frac{3}{4}$ to 1 acre per hour.
,, 36 inches—from 1 to $1\frac{1}{4}$ acres per hour.

The weight of these machines ranges from 7 to 10 cwt. and they can be provided with a trailer seat for the operator mounted on a roller carriage. Their regular use generally compacts the soil sufficiently to dispense with any special rolling implement under normal circumstances.

Examples of these mowing-machines with trailer seats are shown in Plates 34 and 35, but, in place of a roller carriage, a wheel carriage is substituted trailing a 'Sisis' spiking machine in Plate 34, and a 'Sisis' raking and brushing machine in Plate 35.

Areas over 10 acres are more efficiently tackled by gang mowers drawn by tractors. They are arranged in multiple units to give cutting widths as follows:

Triple mower, 7 feet cut.
Quintuple mower, 11 feet cut.
Septuple mower, 15 feet cut.

Taking a mowing speed of 6 miles per hour the areas cut per hour would be respectively, 5, 8, and 11 acres approximately. It is seldom, however, that septuple gang mowers would be required on average playing field work. It will be appreciated also that it would be unprofitable to acquire large equipment of this type for a single small field. Where, however, the equipment is operated by a dual-purpose tractor with detachable tipping body for loading and transporting the cutters, then a large number of fields may be dealt with in rotation provided the time spent in transport is not too great, and that at each field there is ample access for the tractor and room to turn and operate efficiently.

Plate 36 shows a typical sports ground tractor and gang mowers ready for work on an aerodrome.

Gang mowers, of course, do not give the same close cutting as is possible by motor mowers with their greater weight to keep the cutters riding firmly

along the surface. They are, however, excellent for outfield and organized-games areas. They do not compact the soil and therefore separate rolling equipment must be acquired.

Cricket squares, bowling greens, putting greens, and other fine-turf areas where very close cutting is necessary are more effectively dealt with by hand machines of 14- to 16-inch cut. These should have ten-bladed cutters, rigid hollow ground sole-plates, and self aligning ball-bearings.

Rollers. For large areas gang rollers of three units each 4 feet wide giving a total rolling width of 12 feet and an approximate weight of 18 cwt. would meet most normal requirements on sports grounds. Rollers should not be less than 18 inches diameter and should be provided with frames for ballast boxes which can be weighted when necessary.

On smaller grounds a 4 to 6 foot wide single unit for horse or tractor draught would be adequate.

Cricket wickets, of course, require a much heavier roller. A 36 inches diameter by 36 inches wide water-ballast roller, weight 10 cwt. when empty, should be ample for public pitches. The heavy rollers used on county cricket grounds should not be necessary on ordinary playing fields where wickets are not expected normally to withstand more than an afternoon's play.

For bowling greens, putting greens, and similar fine-turf areas, a roller $4\frac{1}{2}$ cwt. in weight, 30 inches diameter by 30 inches wide with balanced handle and roller bearings is useful for spring use to counteract the loosening effects of winter frosts and for occasional use during the playing season when the soil is fairly dry to restore good contact between grass roots and the soil and to encourage the rise of capillary moisture. For regular rolling to smooth the surface for play, a lighter implement is more desirable and a single cylinder elm roller 36 inches wide by 12 inches diameter not exceeding 150 lb. in weight will normally be sufficient.

Hard court rollers for loose waterbound surfaces are generally preferred with the roller in two sections but weight and size approximately the same as for the heavy bowling green roller.

All rollers for grass surfaces should be of the single cylinder type and should have rounded edges to cylinders to reduce risk of damaging the turf.

The 'Sisis' Tru-Level roller effects a marked improvement in rolling technique for fine-turf areas such as bowling greens and grass tennis courts. The weight of 2 cwt. is distributed over three rollers, as will be seen from Plate 37, making contact with the ground in a dead straight line. The effect is therefore similar to using a roller of infinite diameter. It will be readily

understood that the arrangement allows the central roller cylinder to override any hollows or depressions so that any tendency to waving of the surface under rolling is diminished. The operation of a cam gear by a simple movement of the handle will put all the weight on the centre roller when extra pressure is desired.

The implement is easy to push as all rollers run on roller bearings. The machine turns easily on the centre roller which is split for this purpose and ballast bars can be added when increased weight is desired.

Watering equipment. Alternative systems of irrigation have been discussed in the previous section. Where fixed spray lines are installed no further equipment may be necessary, but in the case of movable spray lines or revolving sprinklers it is essential to ensure that sufficient lengths of hose connexions are provided to ensure effective spray cover when watering the areas most remote from the hydrant.

Where there is no piped water-system but there is a stream, well, or other source not too far distant, from which water may be pumped to tank wagons to be transported and distributed over vital areas, such outfits might be a profitable investment in some instances. In this connexion it is interesting to note that 400 gallons distributed evenly over a full-sized bowling green would be equivalent to 0·05 inches of rainfall and, as 0·04 inches of rainfall in twenty-four hours ranks as a wet day in meteorological records, the value of such an application at an opportune time should be appreciated. Water may be transported in hand water-barrows of 30 to 40 gallon capacity or in tank wagons for horse or tractor draught with capacities of from 75 to 450 gallons.

These tank wagons may be fitted with spray lines for direct distribution over the surface or provided with rotary pumps for spraying through lengths of hose to fine-turf areas where heavy traffic would not be desirable. Such equipment is not only useful in times of drought where there are no other supplies of water available, but is effective for applying liquid fertilizers or washing in other chemical applications. A mobile spraying unit is shown in Plate 38.

Other maintenance equipment. There are many other useful labour-saving implements which greatly facilitate maintenance work on playing fields and which can be obtained for operation by hand, horse, or tractor. These include instruments for aeration and surface tillage such as spike rollers and deep-piercing machines, as well as implements for raking and scarifying to varying degrees. In addition there are the usual spike- and chain-harrows, fertilizer

and seed distributors, drag brushes or dragmats, and line-marking machines which should all find a place in the maintenance kit where the maximum efficiency is to be attained economically.

There must always be, of course, occasions when hand tools are necessary for specialized work which cannot be effectively mechanized or for very small areas of patching, reconstruction, or renovation. Small tools would therefore include: turf racers, turf-lifting irons, edging irons, moss rakes, garden rakes, mattocks and picks, digging forks, spades, shovels, draining tools, piercing forks (solid and hollow tined), scythes, billhooks, grass hooks, shears, and a small, long-grass rough-cut mower.

A wooden loot or squeegee is also useful for working in top-dressing to tennis courts and bowling greens.

Keeping ground staff up to date. The science of greenkeeping and turf culture is constantly advancing and the management of every sports field should ensure that their ground organization is kept fully abreast of the latest developments by subscribing to the Board of Greenkeeping Research, St. Ives, Bingley, Yorkshire, so that they may receive their technical bulletins as they appear.

Much valuable research work is also done by prominent commercial firms on all aspects of turf culture and maintenance. Some of these organizations were for a very long time the sole investigators of the problems concerning the establishment and maintenance of sports turf, and their laboratories and experimental stations are equipped with the finest scientific instruments for all phases of this work. It would be folly to ignore their achievements and arrangements should be made to receive latest publications and catalogues from time to time.

At the same time research findings should be treated strictly as a guide to experiment on your own ground. Before using any recommended prescription or proprietary mixture extensively, try it out on a small and unimportant area of the field to test its efficacy under the prevailing local conditions and to become familiar with the method of application. There are often peculiar circumstances which may make a treatment of proven benefit in other cases, inexpedient or inadvisable in yours. Cases are known to the writer where treatment of turf by selective weed-killers has proved disappointing despite the most successful results in other cases. The main difficulty in the unsuccessful cases was, it seemed, an underestimation of the time factor which is of the greatest importance on playing fields in constant use. The grass was checked so badly and was so urgently required that overseeding had to be resorted to.

Probably the treatment might have proven adequate by itself if time were not so pressing.

There is always a danger, too, in home-made compound fertilizers unless the mixer is familiar with the ingredients he is using and the reactions, if any, that may accrue from the mixing. A high-grade proprietary fertilizer is generally manufactured under more hygienic conditions than can be arranged on the ground, and all materials can be tested, weighed, and blended with greater accuracy than would be possible by hand. The resulting product is therefore much simpler and safer to apply and generally more consistent in results than crudely blended home-made mixtures. Just as two cooks may be given the same recipe from which one will produce a wholesome and appetizing dish while the other's efforts may result in nothing more than a burnt offering, so the possession of a first-rate chemical formula or prescription will not always ensure a satisfactory compound.

The art of fertilizing. There is an art in the application of fertilizers just as there is an art in feeding. Everyone knows that to force food even of the most wholesome, digestible, and appetizing quality on a person whose vital functions are severely debilitated might prove fatal. Yet, time after time serious damage has been caused to fine-turf areas by attempts to stimulate a failing growth by liberal dressings of chemical fertilizers or organic manures when the soil was in no condition to absorb them.

If the soil is in poor physical condition, the fertilizers may be unable to penetrate and lying on the surface may rot the foliage. Furthermore, the success of fertilizing depends on the action of certain organisms in the soil which convert the elements into a form more readily assimilated by the plant roots. If the soil is too compacted or water-logged, too acid, too hot or too cold, bacterial activity may be slowed down or stopped. The favourable organisms multiply most rapidly at temperatures between 70° and 100° F., and prefer neutral and optimum soil conditions.

The importance therefore of ensuring a good open tilth to the surface through regular aeration by raking or piercing and careful observation of climatic influences must not be overlooked if results are to be economically obtained. There are of course many more factors of soil science which more or less influence results, but to deal with the matter more fully is beyond the scope of this work, and the subject has already been adequately dealt with in the publications of soil scientists both here and abroad.

Now to some observations on the maintenance requirements of individual sports areas and facilities:

UPKEEP OF FOOTBALL, RUGBY, AND HOCKEY PITCHES, CRICKET OUTFIELD, AND SIMILAR GRASS AREAS:

These areas are generally subject to the most prolonged and severe use and yet are apt to receive no further attention than the requisite mowing and rolling. It is small wonder therefore that most of these areas rapidly become weed infested.

To appreciate the need of adequate maintenance requirements it must be understood that grass is a crop and cannot be expected to give a good yield if it receives nothing in return. If sufficient food and water is denied them, the desirable grasses will rapidly weaken and die off and only the more coarse and undesirable species of plants will move in and occupy the vacant areas if it is at all possible for anything to survive in the circumstances. The operations of the ground staff must therefore be carefully balanced so that root action may not be unduly handicapped by any lack of essential supplies.

Mowing. Every grass playing field requires regular mowing if it is to fulfil its purpose. Football, hockey, cricket outfields, and general areas, however, need not be cut so closely as bowling greens and cricket wickets, but if the grass is allowed to grow rank and the growth becomes tangled, serious sport becomes impossible. The grass should not be allowed to grow longer than 2 inches, and during the growing season will probably require cutting approximately once a week. It is always advisable to bush- or chain-harrow the surface before mowing, to work the grass blades into a more erect position for uniform cutting.

Discretion, of course, must be exercised with regard to the frequency of mowing. It is quite unwise to lay down any time-table. Mild moist weather may necessitate more frequent mowing than once a week, while prolonged drought will probably make it unnecessary to mow.

Mowing should be continued throughout the entire year provided that the growth is sufficient to justify it, but cutting should on no account be carried out if there is any risk of immediate frost.

The question as to whether cuttings should be removed or allowed to lie depends entirely on whether their bulk is sufficient to cause annoyance to players or to smother the grasses. Probably it would be advisable to rake off the first cut in spring if through climatic or other reasons it has not been possible to mow with sufficient frequency during the close season and the growth has become rather heavy. Under regular mowing, however, the

removal of cuttings should not be necessary and if allowed to remain will help to sustain the humus content in the soil.

Feeding. Adequate feeding to replace reserves in the soil which are continually being drawn on by the grasses is an aspect of maintenance which is often overlooked on the more general areas of sports fields. Yet if these areas are allowed to become impoverished and weedy, the work of protecting the more specialized areas from infection is greatly increased. Even where the cuttings are allowed to remain, these can by no means counteract what has been lost. Consequently it is false economy to eliminate systematic fertilizing on general playing field areas because it is considered that a finely textured sward is not essential. These areas are practically in continuous use and are not subject to the seasonal rests accorded to the more specialized sections devoted to summer activities. Consequently the grasses, whatever their nature, have to survive under the most trying conditions, and if not properly sustained by readily available plant foods are bound to deteriorate rapidly.

Furthermore, even on those grounds where water services are available, it is seldom a practicable proposition to arrange for watering during periods of drought to the larger and more general sections of the ground. A vigorous healthy growth, therefore, is all the more desirable where resistance has to be offered to such climatic contingencies. Application of suitable chemical fertilizers at from 3 to 5 cwt. per acre in spring or autumn is by no means extravagant.

Value of compost heap. Wherever practicable a compost heap should be built up as a reserve on every sports ground. Commencing with a layer of soil, the heap should be formed of alternate layers of good loam and decayed organic or vegetable matter. Grass cuttings from various parts of the ground are excellent for the organic layers and the addition of peat or farmyard manure, if available, will further improve the quality. If each organic layer is sprinkled with sulphate of ammonia the rate of decomposition is increased. The top of the compost heap should be finished with a layer of soil or turf and kept covered with galvanized sheets or tarpaulin. The heap should be allowed to mature for six to twelve months, and during this period should be dug over from time to time to ensure thorough mixing. When required for use it should be thoroughly broken down by passing through a $\frac{1}{4}$ inch mesh sieve. This material will be a valuable store of humus for top dressing and may be used to increase the bulk of fertilizers for convenient application.

Humus increases the fertility of the soil by stimulating bacterial activity. It also improves the texture of all soils, conserves moisture, and helps to fix

the soluble plant foods which might otherwise be rapidly leached by rains beyond the reach of the grasses.

Necessity for aeration. Aeration is another operation which must be carefully attended to. It is useless attempting to obtain results from chemical application if the physical condition of the soil is badly impaired. The amount of rolling necessary on sports fields invariably leads to a 'capped' or 'hidebound' surface preventing the free circulation of air and moisture. Under such conditions soil bacteria are either killed or become dormant and root action is diminished. The grass dies off in patches and moss and weeds take possession.

This 'capped' condition is likely to become more marked on those areas subject to the churning and puddling effect of football and Rugby, especially during a very wet season. Accordingly, steps should be taken every spring to thoroughly aerate the surface by means of spike-rolling and spike-harrowing, and if possible the ground should be left in this open condition for a week or ten days before any further rolling is done during the cricket season. Indeed, the periodic use of aerating implements throughout the growing season, especially on grounds of a heavy nature, is always beneficial in encouraging a vigorous growth.

Conserving Moisture. Aerating and scarifying is also of marked advantage during drought as it tends to slow down the capillary movement of moisture in the soil at the lower level of the aerated layer and thereby reduce the rate of loss by evaporation. If, during periods of drought, such aeration can be followed by suitable dressings of compost rich in humus, the conservation of moisture is still more enhanced.

Spike-rolling and spike-harrowing are also effective in tearing out dead growth and should precede all applications of dressings or fertilizers. When such operations are completed in the autumn on grounds of a heavy or sticky nature, if it is practicable to follow up with a gritty dressing, such as finely sifted breeze or gritty sand at the rate of 18 to 20 tons per acre, this will improve the texture of the surface and minimize the tendency to puddling in wet weather. In the case of finely divided clay soils such dressings may have to be repeated at frequent intervals to effect any noticeable improvement.

Rolling. Rolling with heavy rollers should be reduced to a minimum and should never be carried out when the ground is appreciably wet, otherwise on heavy soils the surface will be immediately capped or sealed. Unless demanded by the requirements of play rolling should be limited to such periods as, for instance, after heavy frosts, drying winds, or similar circumstances which may cause contraction of the soil and consequent poor contact

with the grass roots. In such cases rolling is necessary to restore effective root contact, but under all other circumstances rolling should be reduced to a minimum.

Renovation. Reparation and renovation work must not by any means be overlooked in the routine of maintenance. Weak and backward areas which do not respond to the physical and chemical treatments outlined must be dealt with by reseeding or returfing as may be most convenient. Any serious encroachments of weeds must also be dealt with by the customary method of grubbing or by chemical control. Unequal settlement causing pronounced variation in gradients or levels must be attended to in the most appropriate manner at the right season.

GRASS TENNIS COURTS, PUTTING GREENS, AND BOWLING GREENS

These facilities require much more intensive cultivation as a dense sward of fine even texture is desirable. Especially on bowling greens and putting greens any variation in quality of the sward will affect the run of the woods or balls.

Owing to the restricted dimensions most of the work requires to be done by hand or by manually operated implements. Mowing has to be carried out to most severe limits by means of special close-cutting hand machines, and during the season daily mowing is essential for first-class play. Before mowing it is always advisable to drag over the green or lawn with a drag brush to counteract any lateral growth and allow the grasses to be more effectively dealt with by the mower.

Rolling and aeration. Here again the tendency to overdo heavy rolling must be avoided. This to a large extent can be done if the regular daily rolling is carried out with the light elm roller referred to at the outset, which is quite sufficient to smooth the grasses for play. The heavy roller should be used sparingly and only when the greens or courts are in a fairly dry condition, merely for the purpose of maintaining adequate root contact with the soil.

Special attention to aeration is essential here also, although it is not always practical during the playing season unless it is possible to close a rink or court for short periods. It is advisable, however, that this operation should be systematically carried out every autumn as soon as play ceases, by means of hollow-tined or solid piercing forks, turf prickers, or one of the more modern deep-piercing machines. If such work is completed prior to the dressing of sand and fertilizer, which is always essential on all high-grade lawns at this season, the results are much more effective and there will be less risk of 'damping off'

as a result of excessive surface moisture due to winter rains. On heavy soils and sea-washed turf greens where the soil is usually of a very fine texture, the hollow-tined fork is generally more effective and a dressing of vegetable charcoal in addition to the sea sand will, if persevered with, effect a considerable physical improvement in the surface in the course of two or three seasons.

Watering. As it is frequently necessary to resort to artificial watering during dry weather, care must be taken in the time and method of application. Artificial watering can never equal natural rainfall as the applications have to be carried out under the most adverse climatic conditions. It is essential therefore to ensure that the volume of water applied is adequate and that the atmospheric and soil conditions are favourable to rapid penetration to a reasonable depth. It is not advisable therefore to adhere too rigidly to a set time-table. Regular daily sprinklings which hardly go deeper than an inch or two below the surface, only encourage shallow rooting with the result that resistance to drought is diminished. Give water only when the grasses show definite signs of wilting from lack of moisture.

The use of the spike roller or deep-piercing machine before rolling and frequent dragging with the drag brush in addition to setting the blades of the mower a shade higher during drought will help to conserve moisture in the soil by retarding the rate of evaporation. The best time for watering depends of course on the actual needs of the soil, but the reasonable convenience of the ground staff must also be taken into account. Many investigators declare that the best time for watering is in the early morning after the soil has cooled, and that experiments have shown that results are more lasting than those obtained by late evening applications. On many hot summer days, however, the temperature rises very rapidly after sunrise and evaporation and transpiration are correspondingly increased, and these processes must make serious inroads on this fresh supply of moisture before it has time to penetrate and accumulate a reserve. Late evening watering does, however, allow more time for a liberal application to be made and absorbed, and probably suits the convenience of most groundsmen better as the sprinklers can be set and timed immediately play has ceased and an exceptionally early start in the morning is avoided. It should be remembered that on sports fields a groundsman has many important matters to attend to if facilities are to be got ready for the day's play without adding watering to his early morning duties. It is much better to allow him to suit his own convenience as to the most opportune time, provided he does not persist in the wasteful practice of watering under a hot sun.

The equipment must be capable of applying the water in the form of a gentle spray and with a regular movement so that ponding of the surface is avoided.

Encrustation from use of hard water. A further reason why artificial watering should not be overdone arises from the fact that most district supplies are drawn from deep wells and are more or less of a hard nature. Accordingly, prolonged watering from such sources has a tendency to encourage surface encrustation and to upset the chemical balance by the nature of the residual salts. Very often clover makes an appearance as a direct result of this action. The use of the moss rake periodically in addition to spike rolling before each mowing will help to counteract any encrustation and discourage the spread of undesirable herbage.

Adequate fertilizing essential. Whatever may be the opinions as to the advantages of fertilizing on football fields and cricket outfields, there can be no argument against the need for adequate action in this respect where fine swards are required as for bowls, tennis, or golf. The continual close mowing and the impossibility of heavy compost dressings make it essential that the plant food balance must be maintained by means of suitable artificials. In early spring a good dressing of a high-grade complete lawn fertilizer at the rate of not less than 2 oz. to the superficial yard is advisable. This should be mixed with sufficient sharp, clean sand to increase the bulk for easy distribution. Whether or not a further application about midsummer at half the above rate is necessary must depend on the condition of the turf and the prevailing climatic circumstances. Applications of fertilizers in very hot weather are not to be recommended as under high temperatures bacterial activity in the soil is diminished and consequently without this bacterial co-operation the roots are unable to benefit from the applications. Autumn requires a further application of chemicals. At this period, however, forcing inorganic chemicals are best avoided. A mild organic application such as fish-meal is excellent for restoring the grasses and stimulating root action during the winter months.

Sand dressing. The type of sand to be used for top dressing is often a matter of debate. Sand has little or no manurial value. Its action is purely mechanical in improving the soil texture. Sea sand from certain parts of the coast contains a percentage of carbonate of lime in the form of crushed shells and in such cases might have a slight antacid value. Unless it can be purchased at a reasonable figure, however, it is hardly worth considering in this respect if a good washed gritty pit sand is obtainable. If an acid soil condition has to be counteracted, it is much more effectively dealt with by a definite application

of a small quantity of hydrated lime with the sand or, if preferred, charcoal. Many sea sands in any case contain no appreciable shell-compost and are practically pure silica.

Disease and insect pests. Other contingencies which have to be reckoned with are possible attacks by insect pests and fungoid diseases. If these are allowed to become widespread considerable trouble and expense may be necessary to eradicate them and repair the damage to the turf.

So much has already been written on these subjects that there is no need to cover the same ground with details of symptoms and methods of control. It is sufficient here to say that science has placed at the disposal of groundsmen a wide range of simple and reliable remedies for such turf ailments, and these can be readily procured from any reputable horticultural suppliers in a convenient form for easy application. There is therefore no reason why these affections should not be dealt with before extensive damage is done.

Of course prophylactic methods should not be overlooked, and it will be found that where the soil is kept in a sound physical condition and the plants well nourished there will be a higher resistance to attacks by fungi, while the occasional use of a soil fumigant such as powdered napthalene will often discourage insect invasions. The napthalene should be applied at the rate of 2 oz. to the square yard. To ensure even distribution it can be increased in bulk by adding sand, and the application should always be well watered in.

Other everyday remedies for the more common turf infections are:

Worms. Perhaps the most lasting results are obtained by the use of lead arsenate in either powder or semi-liquid form. Powder form is probably most easily applied by mixing 1 lb. with about 1½ to 2 cubic feet of sand and distributing over 20 square yards. Colloidal or semi-liquid should be diluted at the rate of 1 oz. to a gallon of water and applied to one square yard. Lead arsenate is poisonous and must be handled with care.

Leather jackets (crane-fly grubs). These pests can also be dealt with effectively by lead arsenate. There are, however, many other reliable proprietary mixtures which are quite effective.

There are many diseases of fine turf caused by various fungi. To attempt to describe their appearance for diagnosis by the inexperienced is always dangerous in the writer's opinion. If the turf is drying off in patches or is affected by some types of rust or mould it is much better to have the trouble properly diagnosed by a competent specialist so that the effective remedy may be prescribed at the outset. Samples of the affected turf could be sent

to the Board of Greenkeeping Research or the research stations of prominent seed firms. Better still, if the area affected is extensive, to have a personal visit of inspection by an expert plant pathologist. This may save the wasting of much time, labour, and expense on ineffective attempts to control the disease.

Weed control. Hand weeding is much too laborious and costly to be considered in these days except on very restricted areas. The most popular method of control in the past was by means of lawn sand in which the active ingredients were sulphate of ammonia and sulphate of iron, but its success was limited especially in relation to many of the most persistent turf weeds, such as plantains and dandelions.

Since the war much progress has been made in the development of selective weed-killers which can be applied in spray or powdered form. The active ingredients are synthetic hormones or chemical agents designed to stimulate abnormal and unbalanced development in the bodily structure of the weeds to their ultimate destruction. Astonishingly successful results have been achieved in some cases, but considerable care and experience are desirable or extensive damage may be done to the grasses.

Spring and early summer appear to be the best time for this treatment and both grasses and weeds should be growing vigorously when the applications are made. To promote this it is sometimes advisable to give a dressing of sulphate of ammonia or other nitrogenous fertilizer at the rate of $\frac{1}{2}$ oz. to the square yard (or $1\frac{1}{2}$ cwt. per acre) about ten days before applying the weed-killer.

Warm settled weather is desirable to obtain the maximum efficiency, and the death of the weed is gradual and may take eight weeks or more before complete eradication is achieved.

The powdered form is applied at the rate of 1 cwt. per acre, bulked with sufficient fine sand, screened compost, peat, or soil to ensure an even coverage of weed foliage.

The liquid form is diluted at the rate of 12 gallons to 100 gallons of water applied to one acre. Indications to date seem to indicate that more effective results are obtained from liquid applications.

Extensive applications should in the writer's opinion be carried out by experts with suitable equipment to ensure the correct dosage in accordance with the local conditions.

The main problem in the application of these methods to public playing fields will probably be the time factor.

CRICKET SQUARES

The foregoing remarks apply largely to the treatment of cricket tables with the exception that it is impossible to dispense with the use of heavy rolling in the preparation of a firm wicket. At the same time after a wicket has been used the detrimental effects on growth should be immediately counteracted by loosening up the turf over the area of the wicket by driving in a fork at 4 to 6 inch centres at an angle of 45 degrees and gently depressing the handle before withdrawing so as to lift the turf from the roots upward. The wicket should be allowed to stand for a few days in this condition before restoring the surface by a light rolling. Only the width of each wicket (say 8 feet) should be closely mown as required. The general area of the square could be left a little longer with advantage to the conservation of moisture.

Sand should never be used for top dressing cricket tables.

The elaborate preparation of heavily marled wickets is perhaps neither practical nor advisable on public playing fields, but where the soil is of a light and friable nature the inclusion of a proportion of marl in the autumn top dressing annually will assist greatly in improving the wickets and reducing the liability to crumble.

HARD TENNIS COURTS AND DRY-SURFACE PLAYGROUNDS

The permanent non-upkeep or chemically bound type of surface such as tar macadam, asphalt, &c., will require little attention beyond an occasional sweeping of the surface with a soft broom to remove any large pieces of grit likely to crumble the surface under the player's feet or to remove any leaves which when wet are apt to make the surface slippery and treacherous. A periodic touching up of the marking lines will also, of course, have to be reckoned with. If the surface has been coloured by spraying with emulsion this colour spray will probably have to be renewed every second or third season, according to climatic circumstances, intensity of play, and local taste in the matter. In some cases the binder may become brittle and the surface commence to fray or crumble. Should such a tendency be noticed a respraying with binder emulsion and re-rolling should be carried out at the earliest opportunity.

Loose-surface courts of the water-bound gravel, crushed-granite, or brick-dust type must be kept moist and well rolled. The surface requires to be dragged over every morning after play to redistribute the disturbed surface material, after which the surface should be well watered and rolled. In dry

weather application of deliquescent chemical salts such as calcium chloride or sodium chloride, which are readily obtainable and economical to apply, are effective in reducing the amount of watering to a minimum and also in discouraging encroachments of moss. Applications at the rate of 4 to 6 oz. to the superficial yard require to be renewed after rain.

Loose-surface courts must not be allowed to become too tightly bound so that the drainage is impaired. Should such a condition arise where water does not readily penetrate through the surface it is necessary to fork over the entire areas affected with a straight-pronged piercing-fork driven well down into the ash foundation at 4 to 6 inch centres and worked gently to and fro before withdrawing. Thereafter the surface should be dragged over with the drag-mat or dragbrush and well rolled. As a rule the surfaces of this type require a certain amount of fine top dressing once or twice a year, but if the surface has been well constructed of good quality crushed rock or other material, the amount required for dusting over should not exceed 2 to 3 tons per court per annum.

Generally. Apart from the foregoing brief outline of more or less essential maintenance operations there are such duties as general tidying up, collection and disposal of litter, trimming of hedges, weeding (including paths and drives), protective painting of buildings and fences as may be required from time to time, and the care and repair of the various implements and equipment.

If there is a children's playground the mechanical amusements must be carefully examined from time to time and any defects immediately remedied so that the risk of accidents is reduced to a minimum.

Common rates of application for various dressings:

Organic compost to general playing areas: 20 to 40 tons per acre.
" " " small areas: 8 to 10 lb. per sq. yard.
Lime (when required) to large areas: 1 ton per acre.
" " " small areas: ½ lb. per sq. yard.
Fertilizers (compound) to large areas: 2½ to 5 cwt. per acre.
" " small areas: 2 oz. per sq. yard.
Pulverized peat to large areas: 30 to 50 cwt. per acre.
" " small areas: ¾ to 1 lb. per sq. yard.
Vegetable charcoal for bowling greens and fine lawns: 6 to 8 oz. per sq. yard in autumn.
Sand (½ inch down), sea or washed pit for bowling greens, &c.: 6 to 8 lb. per sq. yard in autumn.
Nottingham marl for cricket tables: 6 to 8 lb. per sq. yard in autumn.

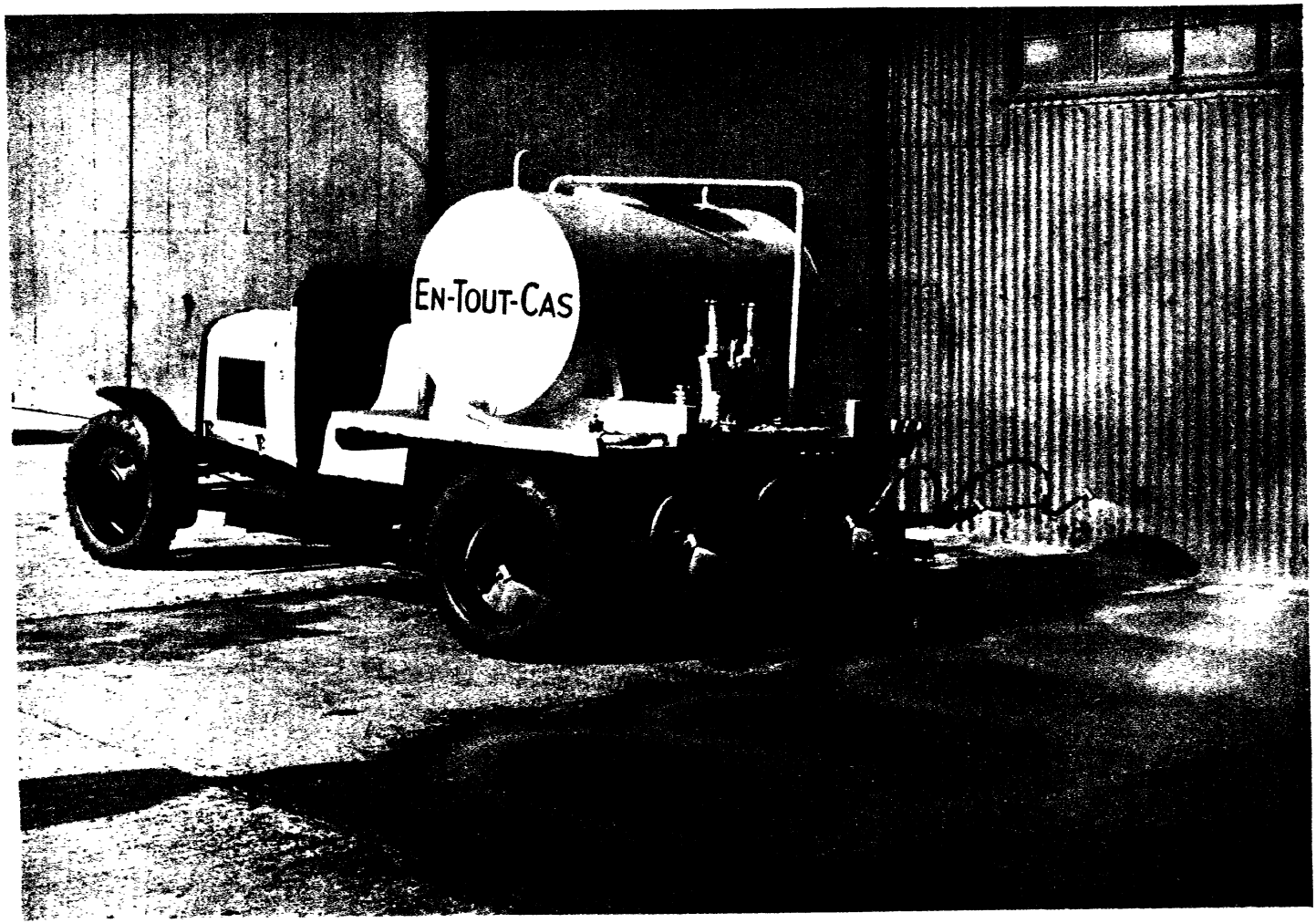


PLATE 38. *A useful mobile spraying outfit for watering or applying liquid fertilizers or other dressings*

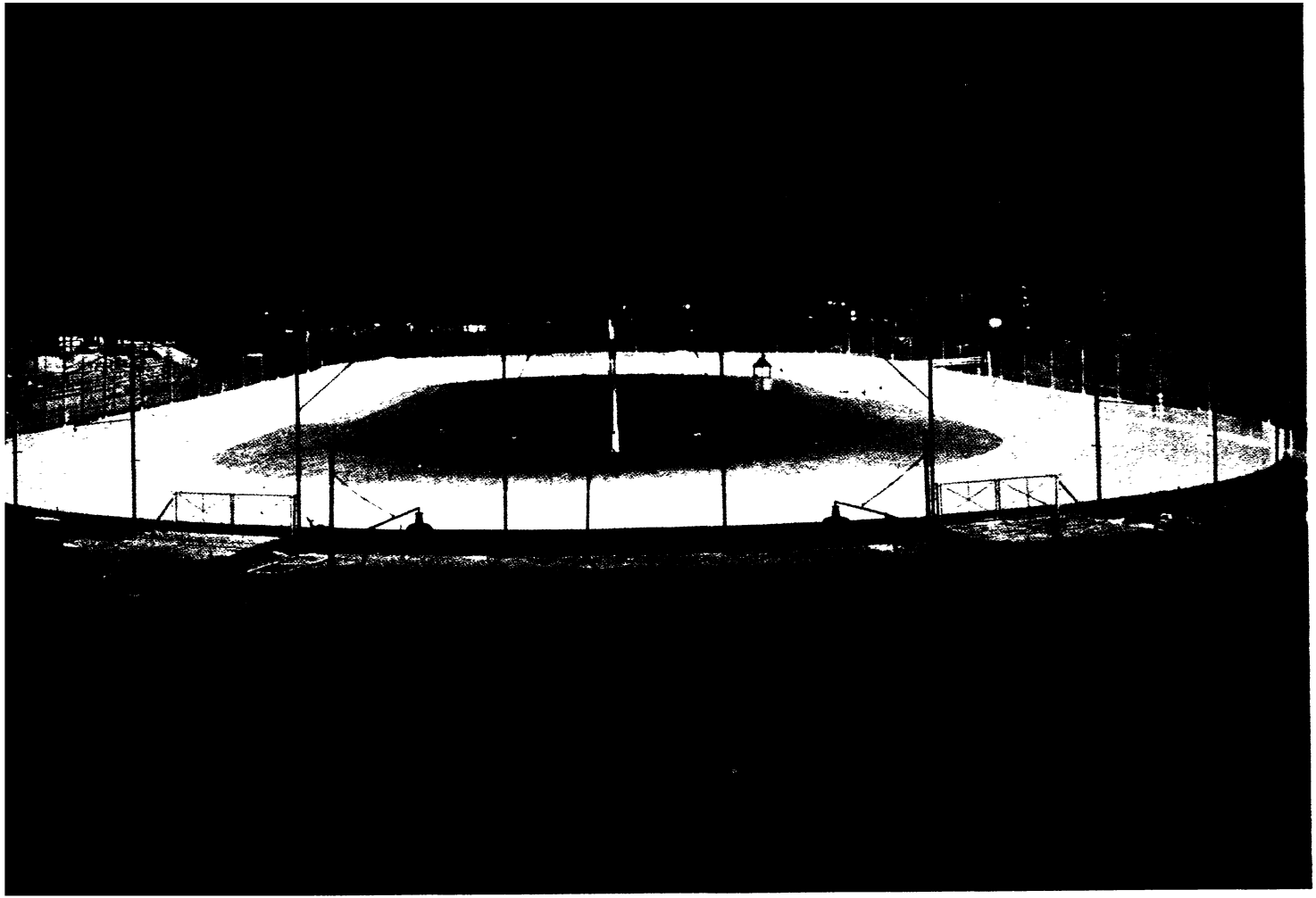


PLATE 39. *A floodlit Greyhound Race Track. The effectiveness of floodlighting for Athletics may be appreciated from this photograph*

Conclusion. From the varied nature and vast extent of this subject of maintenance, it follows that such notes as have been set out above must in consequence be of a rather sketchy character and it can only be hoped that as a result the importance of the problem will be more fully appreciated and that the need for constant study and attention to the relative details will not be overlooked by those whose duty it is to see that playing fields are properly managed. It may also, it is thought, be of service to those concerned with the promotion of new playing field projects by indicating the responsibilities which lie ahead of the initial establishment of such schemes.

VI

THE FLOODLIGHTING OF PLAYING FACILITIES

MUCH valuable outdoor practice and training for athletics and various games has to be suspended on account of the earlier nightfall from late autumn to early spring. Most players can only find time for training in the evenings so that in winter most practice or training exercises have to be taken indoors and there is little or no opportunity for outdoor evening play. Children are also seriously affected by lack of opportunities for safe winter play and are often to be seen romping or roller-skating in busy streets after dark despite the dangers to themselves and other users of the highway.

Floodlighting therefore would greatly increase the opportunities for outdoor recreation during the period of the year when bodily vigour is most essential and is likely to attract children and adolescents into more safe and beneficial forms of amusement than they might otherwise obtain.

The effectiveness of floodlighting for late-evening play has been fully demonstrated at many seaside resorts, where bowling greens, tennis courts, putting greens, and swimming pools have been successfully equipped to afford extended hours of use after dark. Most people, even if they have never attended a meeting, are fully aware of the extent to which dog racing is carried on in the winter evenings. It is pathetic that hosts of athletic men and women should spend their evenings round well-lighted and equipped dog tracks watching sprint and hurdle events contested by diminutive quadrupeds while our youthful games and sports enthusiasts patiently await the return of longer days. What a healthier prospect both for the spectator and athlete if we could have a number of well-illuminated sports stadiums dispersed throughout the country, where regular meetings could be held. The greater opportunities for full-scale training and competitive experience would be of enormous advantage in raising the standard of athletic performances while as a spectacle for winter evenings it would probably prove quite popular with the vast army of athletic enthusiasts who through age or infirmity are no longer active enough to participate.

The photographs that follow illustrate how effective a well-considered scheme of artificial lighting can be for various purposes. Indeed, in some aspects from a spectacular point of view it is sometimes possible to provide

superior illuminated effects at night by artificial lighting than could be achieved in daylight. All surrounding distractions are blotted out at night and the illumination is concentrated solely on the area in use.

Of course the type of floodlight installation must depend on the games facility which is to be illuminated. Games in which the ball has to be constantly sighted in motion from varying positions require careful consideration as regards the location, height, and reflection of the lighting units. For other games such as bowls, curling, putting, &c., where the ball is not played while in motion a general flood of light is required, and if the positions are carefully chosen the mounting heights for the units need not be so great as in the former cases. A distributive rather than a concentrated floodlight is sufficient in these circumstances.

To light an entire football ground effectively for match play would, of course, be very costly. To avoid glare in the eyes of players and spectators the equipment must be mounted on steel-framed towers at least 100 feet above ground level, and one of these towers would be required at each corner of the field. To provide a sufficient intensity of light each tower would have to be equipped with 30 to 40 narrow beam 1,000 watt floods, and reliable pre-set focusing and training devices are essential so that if in the process of cleaning a floodlight is disarranged it will automatically return to its correct position.

The illumination of smaller areas purely for football or scrum practice, however, does not require such expensive and complicated equipment. A much simpler type of installation is available for limited training areas.

For tennis courts ten 1,000 watt lamps in parabolic angle reflectors are recommended, mounted at a height of 25 feet. Five units are fixed along each side of the stop net enclosure spaced equidistant apart between the baselines. A similar type of installation could be adopted for illuminating small play areas for children.

Plate 39 shows the illumination of a typical greyhound racing track, from which it will be easy to appreciate how valuable an athletic track equally well illuminated would be for winter sports meetings and practice.

Plate 40 shows the municipal bowling green at Colwyn Bay, floodlit for evening play. Plate 41. A floodlit miniature golf course at Bognor Regis. Plate 42. Floodlit tennis courts at Colwyn Bay.

In floodlighting turfed areas such as bowling greens, golf greens, grass tennis courts, &c., consideration must be given to measures to avoid excessive wear. If grass is to be subject to intensive traffic both night and day it will not

survive for long, and any increased revenue from late evening play may be more than offset by expenditure on renovation and replacements.

This question of overplay and heavy maintenance must be carefully considered before floodlighting any facility.

The author is indebted to the Illuminating Engineering Department of the General Electric Co., Ltd., for the information given in the notes and for the photographic illustrations used.

VII

SPECIFICATION OF PLAYING FACILITIES

INTRODUCTION

THESE outline specifications have been drafted in response to numerous requests for guidance in relation to the constructional requirements of the various playing facilities more generally included in public playing field schemes.

They were submitted to a special technical sub-committee of the National Playing Fields Association comprising representatives of the following professional and trade organizations:

The Royal Institute of British Architects.
The Royal Institution of Chartered Surveyors.
The Institution of Municipal Engineers.
The Institute of Park Administration.
The Town Planning Institute.
The Institute of Landscape Architects.
The Miners' Welfare Commission.
The British Association of Field and Sports Contractors.

While the original draft specifications met with general approval some minor revisions were suggested by various interests on practical, economic, or expedient grounds, and these have been incorporated in the appropriate clauses or have been dealt with in the special preliminary notes on the use of these specifications.

In publishing these specifications the Association is fully conscious of the difficulties that may arise in many cases if an attempt is made by the uninformed to enforce too rigidly general principles, such as those outlined, in particular circumstances where the need for some modification or amplification would be clearly obvious to the experienced practitioner. It must be stressed therefore that these specifications are merely suggestive and are intended to outline good constructional procedure under normal conditions, but may require considerable adjustment in special cases.

It is strongly recommended that all promoters of playing field projects should retain the services of a suitably experienced professional consultant—landscape architect, architect, civil engineer, surveyor, or parks designer—

who would be competent to advise them to what extent these specifications should be applied in inviting tenders in any particular circumstances.

Economic, climatic, and locational influences must be carefully considered in deciding the most suitable method of construction, and, even where a satisfactory specification has been evolved, adequate expert supervision is essential during the progress of the work to ensure that the terms of the contract are being fully complied with.

Many of the specifications drawn up by commercial specialists in competition with others are often phrased in such a vague, ambiguous, or equivocal manner that it is impossible to obtain any definite conception as to the extent and quality of the materials or workmanship included in the tender, or to arrive at any common basis for comparison with other offers. It is hoped that the use of these specifications will overcome these difficulties and that specialist contractors will in future base their offers on the recommendations made as far as may be practicable and state the difference in price for any alternative proposals which their experience may show to be desirable.

It must be emphasized that guarantees and the period of liability for defects should receive special consideration in respect of proprietary methods of construction.

Grass seed mixtures. The Association strongly recommends that the opinion of a consulting agrostologist should be obtained as to the most suitable mixtures of grass seed and rate of sowing to be specified. Many of the leading firms of seedsmen retain research botanists and soil chemists and have well-equipped laboratories for carrying out soil tests. In many cases these services are available to applicants for a nominal fee, and full advice as to the best mixture obtainable for the purpose for the time being and rate of application may be arranged on application to them. This, of course, should always be adopted where the area to be sown is appreciable.

The seed mixtures given in the specifications herewith are those from which a satisfactory turf has been established in various parts of the country when sown at the rates indicated and even at much lower rates. The supply position is, however, by no means stable and alternatives may have to be used when certain species are unobtainable. Where expert advice is available it is always better to obtain a special prescription to suit local conditions.

SPECIAL EXPLANATORY NOTES ON THE USE OF THE SPECIFICATIONS

Liability for defects. The difference in the periods shown in Clause 10 (General Clauses and Conditions of Contract) for grass areas completed in

spring or autumn was considered advisable by the representative of The Institute of Landscape Architects. It was thought that work completed in the autumn might relieve the contractor of responsibility before any growing weather had been experienced if the period of liability was limited to six months. Employers are therefore advised to consider this aspect carefully before specifying the period of liability for defects.

Licences for removal of trees. It must be understood that before any trees or standing timber can be removed a permit must first be obtained from the Board of Trade (Timber Control) and this applies to all standing timber, 3 inches diameter and over at breast height. Should the proposed development therefore necessitate such clearance the employer must before the commencement of the work obtain the necessary permit and inform the contractor regarding any special procedure to be adopted in disposing of the timber under Section 1 of Specification Clauses.

Quality of materials. All materials specified shall be the best of their respective kinds and shall conform to the standards laid down by the British Standards Institution whenever practicable.

Coarse clinker unless where otherwise specified shall be well-burnt, hard, clean boiler clinker to pass 3 inch and be retained on $\frac{3}{4}$-inch mesh screen.

Fine clinker ash unless where otherwise specified shall be of similar quality but graded from $\frac{3}{4}$ inch to fine.

Mixed boiler clinker may be used provided all pieces larger than 3 inches are broken down and sufficient fine material is screened out for the blinding to conform reasonably to the grading mentioned above.

Where clinker is not readily available other clean hardcore may be used such as broken stone, gravel, broken brick, or concrete, graded as before described.

Cement. All cement used shall be best Portland cement of British manufacture.

Cement mortar where specified shall be mixed in the proportions of 1 part cement to 3 parts clean sharp sand.

Portland cement concrete unless where otherwise described shall be mixed in the proportion of 1 part cement, 2 parts sand, and 4 parts broken stone, clean gravel, crushed brick, or other suitable material.

Sand to be clean and coarse; graded from $\frac{3}{16}$ inch to fine.

Broken stone, gravel, &c., to be of varying grades between 1 to $\frac{3}{16}$ inch.

All materials to be free from clay, loam, or organic matter.

All-in ballast, graded 1 inch to fine, may be used provided it is clean.

The mixture in such cases would be 1 part cement to 6 of ballast. Materials shall be mixed together with the minimum amount of clean water that will give a workable and plastic concrete. Sloppy or very wet concrete shall be avoided.

No concreting to be undertaken at temperatures under 36° F.

Soil amendments. The dressings suggested under Section 5 may not be fully necessary. The rates of application specified are those most generally adopted on sports field construction. Where possible to obtain soil analysis and expert advice as to the soil improvements necessary it is better to do so, especially where extensive areas are to be cultivated.

At the same time the dressings must not be considered purely from the horticultural angle. Surface playing conditions as they may be affected by the traffic of play and maintenance must also be considered, and in this respect applications of peat or lime may help to bind the more open soils. Lime also promotes flocculation of clay soils and the incorporation of peat in addition to adding humus will help to resist the tendency to excessive compaction under rolling or play.

Heavy cohesive soils may also benefit by application of gritty materials such as fine breeze, charcoal, or coarse sand applied at the rate of about 15 to 30 cubic yards per acre and lightly harrowed into the surface, when supplies can be obtained at economic rates.

Rates for seeding. The rates for seeding specified in Sections 6, 7, 8, and 9 are in accordance with fairly common practice in the establishment of playing fields throughout the British Isles. Much lighter sowings with suitably proportioned mixtures have, however, given satisfactory results. In many cases, however, the saving in the cost of seed has been more than offset by the more intensive treatment demanded before and after seeding to establish a clean strong growing turf suitable for games. Too light a sowing may also cause delay in establishment. Before embarking on experiments in this direction therefore it is advisable to obtain suitable guarantees that there will be a definite saving in cost and no loss of time in having the field available for play.

Hard tennis courts. In examining proprietary specifications it is important to see that the fullest information as to the type of surfacing is stated in relation to the following:

(*a*) The quality of broken stone, crushed brick, or other aggregate used.
(*b*) The limits of grading in size of the particles.
(*c*) The method of laying, whether screeded on in one or more layers.

(*d*) The consolidated depth and the tonnage used per 100 superficial yards of surface.

(*e*) The type of binders used, if any, and the rate of mixing per ton of aggregate where pre-mixed, or the rate of application per superficial yard where grouted.

(*f*) Method of colouring, if any, and marking out of surface.

(*g*) Estimated normal annual allowance for maintenance and depreciation, or probable life of surface.

Bowling green ditches. For the framing of bowling green ditches (Section 14, clause 5) creosoted timber is much to be preferred where the necessary licence can be obtained for its use as it can be arranged to give fuller support to the edges of the turf than is possible with concrete kerbing which if exposed may scratch or damage bowls. As the level of the green tends to rise gradually through the annual top dressings, adjustment of the edge support is quite simply effected by adding fillets to the top of the timber board when necessary.

In districts of heavy rainfall some may prefer to omit the mixture of soil with the ash covering to the coarse clinker, and merely bed the turf on sand as may be necessary. Many are now convinced, however, that soil does promote a healthier root-growth, retains moisture in dry weather for longer periods, and more effectively fixes the applications of plant foods.

There are also prominent horticulturists who consider it unnecessary to top dress with fertilizer before the turf is established, where fertilizer has already been incorporated with the bedding layer below. The method specified, however, is in accordance with fairly old established practice and results in our experience have been consistently good. Where preferred, however, the specification can be modified in these respects.

Running tracks. The cinder-track specification as detailed in Section 18 is one which should function well under most average conditions. Climatic influence and the time of the year the track will be most in use, however, must be taken into account and in very wet situations the amount of clay may have to be reduced or entirely eliminated and fine ash substituted. For meetings under dry, summer conditions, however, where an unlimited water-supply and efficient appliances for rapid spraying are not available the clay greatly assists in binding the track surface.

There are, however, excellent tracks formed purely of clinker and fine ash, the grading and depths being as specified, and the fine ash blinding being repeatedly brushed, watered, and rolled to thoroughly pack the interstices.

They usually take a little longer to settle down and if an efficient watering installation is not installed frequent deliquescent applications may be necessary at the commencement of dry periods to keep the surface moist and well bound.

Red tracks may be formed by using red ash from the colliery tips, suitably graded as specified for clinker and using fine dust from crushed bricks ($\frac{1}{8}$ inch to dust) for filling and blinding. Such tracks, however, are much too costly for recommendation on normal public playing fields.

GENERAL CLAUSES AND CONDITIONS OF CONTRACT

1. *Conditions of Contract*

The contractor shall include in his tender for entering into a contract with the employers in accordance with the Articles of Agreement and Conditions of Contract drawn up by the Royal Institute of British Architects; reading, in place of the term 'building' wherever used, 'the works hereinafter specified'.

2. *Drawings and Specifications*

The accompanying drawings and specifications are intended to convey an accurate description of the nature, extent, and standard of quality of the work to be performed by the contractor. Should the contractor be in any doubt regarding the true meaning and intent of any clauses in the conditions of contract, specifications, or details shown on the drawings, he is invited to have these fully resolved before submitting his tender, as no extras will be allowed for any loss or expense involved through any misunderstanding arising from his failure to comply with this invitation.

3. *Provisional Sums*

The tender must include for carrying out the work strictly in accordance with the true intent and meaning of the drawings and specifications and shall include such provisional sums as may be specified and which the employers may deduct wholly or in part as may be applicable.

4. *Labour, Plant, &c.*

The contractor shall supply all labour, tools, plant, and equipment necessary to the efficient execution of the works, and shall provide such storage sheds, canteens, latrines, and shelters as may be required to comply with any statutory regulations, and shall maintain same during the contract in a thoroughly sanitary and hygienic manner and clear away on completion to the satisfaction of the employers.

5. *Working Conditions*

The contractor shall observe the hours of working, conditions, and rates of pay in strict accordance with any agreements negotiated between employers and the trade unions concerned.

6. *Water for the Work*

The contractor will be at liberty to use the employers' water-supply for the purpose of the works free of charge, but will have to supply the necessary hose or temporary piping, &c., required, and exercise due care in the use and maintenance thereof to avoid waste.

7. *Excavations*

Excavations of earthwork included for in the tender of the contractor will include for working in any material capable of being dug in by hand or mechanical means. Where excavations have to be carried out in rock, stone brash, or running sand the contractor shall agree with the employer an extra price in accordance with the work involved.

8. *Disposal of Surplus*

Where excavations apart from the major site levelling are specified to be disposed of 'where directed on site' the contractor shall agree with the employer beforehand as to the average length of haul between the cut and fill. Where no distance is specified the tender shall be deemed to include for wheeling, spreading, and levelling surplus excavations from trenches, foundations, or similar sectional operations where directed within a distance of 60 linear yards from point of removal.

9. *Removal of Plant*

Any plant brought to the site by the contractor shall not be removed without the written consent of the employers. Such consent will not be unreasonably withheld from the contractors provided the employers are satisfied that such removal will in no way jeopardize the progress or quality of the works.

10. *Liability Defects Period*

The period during which the contractor shall uphold the works against any defects due to faulty workmanship or materials in accordance with Clause 12 of the R.I.B.A. Conditions of Contract shall be:

(*a*) Six months from certified date of completion in the case of all grass surfaces (pitches, courts, greens, or lawns, &c.), where sowing or turfing has been completed in the spring. Nine months where these works are completed in the autumn.

(*b*) Twelve months from certified date of completion in the case of all hard surfaces (dry playground, hard tennis courts, running tracks, entrance roads, access paths, car parks, &c.).

11. *Payments*

Payments to be made at monthly intervals to the extent of 90 per cent. of the estimated value of the work completed to date. The balance to be paid 5 per cent. on certified completion of the work and the remaining 5 per cent. at the end of the maintenance period provided all the conditions in respect of rectification of defects have been complied with.

In valuation for interim certificates 80 per cent. of the value of any materials delivered on site but not fixed may be taken into account.

Interim certificates will not normally be issued where the total value of the amount of any payment would be less than £100.

12. *Clear away*

The contractor shall clear away all surplus materials on completion and leave the site in a clean and tidy condition.

TYPICAL SPECIFICATIONS

GENERAL GRASS AREAS FOR TEAM GAMES OR IMPROMPTU PLAY

Work to include:

SECTION 1. *Clear Site*

Cut down all trees which may interfere with the development as shown on plan and for which the necessary permit has been obtained from Timber Control (Board of Trade) and dispose of arisings as may be directed. Grub up all hedges, undergrowth, stumps, roots, &c., and burn or otherwise dispose of as may be directed.

Break up any visible foundations, roadways, and similar obstructions and clear site of all tins, rubbish, large stones, or any material detrimental to the establishment of a good turf sward. Any materials which cannot be conveniently destroyed by burning or burying are to be removed from the site to a shoot provided by the contractor at his own expense.

Clearing operations are to be carried out in such a manner that the surface can be freely worked to a depth of 9 inches without damage to the agricultural implements employed.

SECTION 2. *Preparing, Cleaning, and Grading*

(*Note.* Applicable only where surface contours are sufficiently good for games without major levelling.)

The whole site to be thoroughly broken up by plough, cultivator, disk-harrow, rotary cultivator, drag-harrow, chain-harrow, or other suitable means at the contractor's disposal and all vegetable matter brought to the surface by such operations to be collected into heaps and burnt, the resultant ashes being distributed over the area.

Thereafter the surface of the entire field is to be regulated by means of mechanical scoops, approved type blade grader, or road drags, to leave the surface to smoothly running contours free from any pronounced mounds or depressions. The use of heavy rollers for the purpose of rolling out high places will not be permitted. Grading must be carried out by actual give and take movement of the soil as may be necessary.

At the same time operations must be so arranged that there will be at no point a less depth than 4 inches consolidated of the existing surface soil forming the finished surface after grading is completed.

The contractor is therefore advised to walk carefully over the ground and make such allowance for stripping the top-soil before grading and replacing after grading on those areas, if any, where the degree of adjustment necessary to produce the desired surface uniformity demands such action in order to comply with the minimum soil requirements stated. This minimum depth of surface soil after grading will be strictly enforced. The contractor is advised to agree with the employer before commencement over what areas, if any, the surface soil must be stripped to conform with these instructions.

If, after grading is completed, the upper layer of the soil within a depth of 9 inches from the surface is considered by the supervisor to be unduly compacted as a result of prolonged operational traffic, or working under unfavourable conditions, the contractor shall loosen same to the required depth over such areas, as may be ordered by transverse operations of the cultivator followed by chain-harrowing and due allowance must be made in his tender for such a contingency.

Thereafter the surface is to be rolled as may be necessary by means of suitable agricultural rollers to leave a firm even surface, free from local undulations. Any pronounced depressions or ridges showing after rolling to be made good by regrading as before described.

The contractor shall allow an amount under this section of his tender for obtaining from the site or elsewhere the necessary soil required for filling

ditches (after these have been cleaned, graded, and piped as described under drainage) to bring same to uniformly graded surface with the adjoining fields.

SECTION 3. *Major Levelling*

The surface soil over the areas to be major levelled is to be stripped to a depth of 6 inches and removed to spoil heap in convenient position for subsequent respreading after levelling has been approved.

The subsoil shall then be levelled off to the lines as indicated on the drawings. Excavated materials to be wheeled and deposited where filling is required, put down in layers not exceeding 6 inches deep and thoroughly consolidated. The levelled area to be brought to a uniformly true surface by transverse operations with the blade grader, road-drags, or similar means.

Pick up top-soil previously laid aside in spoil heaps and wheel and deposit to a uniform depth (not less than 6 inches consolidated) over the area levelled, and uniformly grade to smooth finish and roll firmly as before described.

Notes. The contractor must carefully select the site of his soil dumps so as not to interfere with the sequence of operations as any further double-handling necessary through lack of foresight in this respect will not be recognized as an extra.

Allowance must also be made in his price for any cultivations necessary to counteract excessive compaction of subsoil surface due to operational traffic, before replacing top-soil. Such cultivations, where ordered, to be carried out to a depth of 9 inches.

Slopes at limits of excavation and filling to be trimmed off to a uniform batter not exceeding 1 in 1, soiled and seeded as described under Seeding.

SECTION 4. *Drainage*

All existing ditches shall be cleaned out and properly trimmed to the maximum uniform gradients permitted by the general configuration of the ground, or to the definite levels indicated. These ditches to be piped with pipes of the dimensions indicated on the drawings.

Main and submain drains to be of the diameters and laid to gradients indicated on drawings.

All pipes unless otherwise specified shall be best quality agricultural land drains, well burnt, and true bore.

Drain trenches should be of the minimum widths practicable to permit accurate laying and alignment of pipes, which should be laid with closely butted joints surrounded with a thin layer of wheat straw, or the upper part of each joint protected with a layer of waterproof paper, turf with roots

uppermost, or other means to prevent fine material or grit entering the pipes during back filling.

Main drains and submains in trenches or ditches to be back filled with clean boiler clinker, broken stones, or shingle (3- to $\frac{3}{4}$-inch gauge) carefully packed around and over pipes to a depth of 9 inches from surface. The remainder of the trench to be filled with soil from the excavations, the upper 6 inches to be good top-soil obtained from site or elsewhere. Filling to be carefully rammed and consolidated.

Main drains to be connected to nearest outfall drain or ditch. Catchpits to be provided, where indicated measuring 2 ft. 6 in. by 2 ft. 6 in. internally of 9-inch brickwork in cement mortar. Bottom of pit to be 6-inch thick Portland cement concrete (1 to 6) with top of floor 12 inches below invert of drains. Including rendering internal face of brickwork in cement mortar and providing approved 4-inch thick reinforced concrete covers in four sections, with rebated joints and countersunk lifting rings to each section, finished flush with surface of ground.

Where outfall discharges into existing stream or ditch the bank of the watercourse to be protected against scouring by Portland cement concrete slab 6 inches thick finished flush with general slope of the bank and extending at least 1 ft. 6 in. beyond outside of pipe in all directions. Pipe to be trimmed off flush with face of concrete and protected against access of vermin by a galvanized iron grating over the end of the pipe, securely fixed to concrete.

Intermediate or subsidiary feeder drains to be laid to lines as shown on drawings connecting to mains and submains in herring-bone fashion, or at an acute angle.

Feeder drains unless otherwise stated to be 3-inch diameter agricultural land drains of best quality, laid to proper gradients with a depth to invert of pipe not less than 1 ft. 6 in. Pipes to be laid to proper alignment and protected by a layer of wheat straw well packed around and over the pipe, and trenches back filled with the soil previously removed, the upper 6 inches to be good top-soil obtained from site or elsewhere. Filling to be carefully rammed and consolidated.

Any surplus soil from trench excavations to be utilized as far as practicable in general levelling over the site. Where this is impracticable surplus is to be carted from site to a shoot provided by the contractor at his own expense.

SECTION 5. *Liming and Fertilizing*

(*Note.* Delete those dressings which are not required.)

Dress the ground with hydrated lime at the rate of 1 ton per acre and work into the surface by spike-harrowing or light disking.

Dress the ground with granulated peat at the rate of 30 cwt. per acre followed by light disking and chain-harrowing.

Dress the ground with approved fish guano, or other approved grassland fertilizer of equivalent value, at the rate of 5 cwt. per acre applied in two equal sowings (2½ cwt. per acre each). The second application to be carried out in a transverse direction to the first.

No chemical application to be made before the surface has been approved and sanction given by the supervisor who must also be notified when each operation is to commence.

All fertilizers and chemical dressings to be supplied in non-returnable bags and the specified quantity conveniently apportioned over each acre for filling the distributors. Applications to be made by modern broadcast distributors wherever possible.

Signed delivery notes shall be handed to the supervisor with the guaranteed analysis of the mixture, and after each application the empty bags are to be collected by the contractor in a convenient place where they will be checked by the supervisor before permission is given for burning on the site, or removal as may be most expedient.

The contractor shall deliver the necessary fertilizer and other dressings to the site at least ten days before the intended application and the employer shall be at liberty to take samples from any part or parts of the consignment for detailed chemical analysis.

The surface shall be finally chain-harrowed (after working in dressings) in transverse directions and rolled with a 'Cambridge' roller.

SECTION 6. *General Outfield Seeding*

Before seeding, the site shall be cleared of all large stones (over 3 inches) or other detrimental matter brought to the surface during previous cultivations.

At a suitable season and not within seven days of the foregoing application of fertilizer the area to be seeded down at the total rate of 2 cwt. per acre (applied in two equal sowings, in transverse direction, of 112 lb. each) by efficient broadcast machine.

The conditions governing the supply of the seed and the method of application shall be in all respects similar to those specified for the fertilizer.

Seeds to be lightly harrowed in and the surface finally rolled to consolidate.

The seed mixture is to be as follows (or as may be prescribed to suit

PLATE 40. *A floodlit Bowling Green. While players appreciate opportunities for play after dark, dangers of overplay on the turf must not be overlooked*

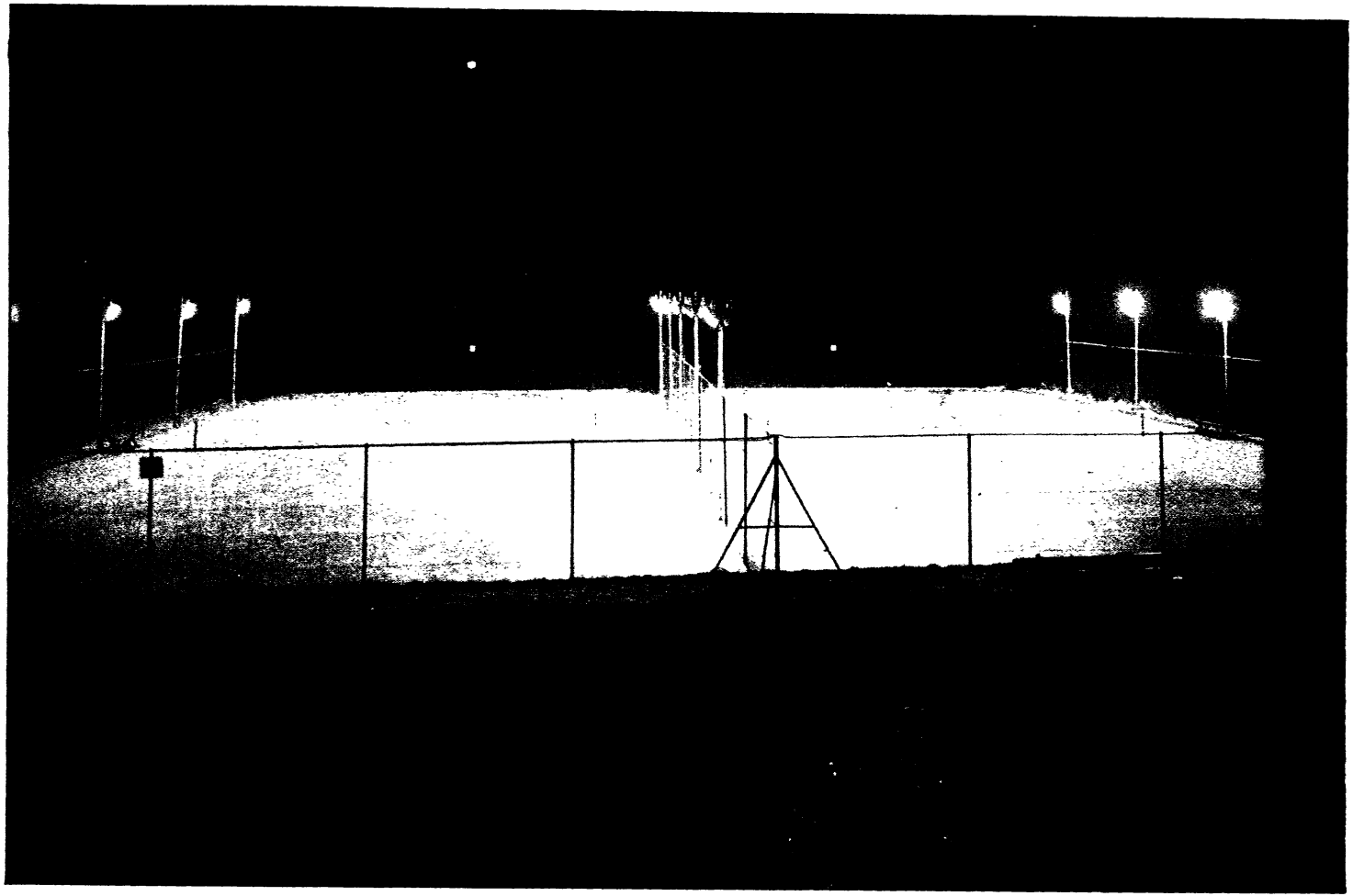


PLATE 42. *Effective floodlighting of Hard Tennis Courts*

special conditions). The particulars requested concerning the individual species of grasses comprising the mixture must be stated as indicated:

		Origin	*Date of harvest*	*Purity*	*Germination*
60 per cent.	Short Seeded Perennial Rye Grass .				
20 ,,	Chewings Fescue .				
10 ,,	Poa pratensis .				
10 ,,	Agrostis tenuis .				

Percentages by weight.

SECTION 7. *Seeding of Cricket Squares, Practice Wickets, and Cricket Ranges*

The special requirements in respect of levelling and marrying in these areas with the adjoining outfield is to be included under the previous Sections 2 and 3 covering grading and levelling as may be necessary.

Where the soil is of a stony, gravelly, or sandy nature, sufficient top-soil should be screened through a $\frac{3}{4}$-inch mesh screen, and mixed with an equal quantity of sifted clay or marl to an even consistency, and spread over the area to be seeded to a uniform depth of not less than 3 inches consolidated. If preferred, the contractor may supply sufficient clay loam free from stones to cover the area to a depth of 3 inches consolidated, including the necessary excavation and disposal of surplus.

Dress the area with approved fertilizer at the rate of 2 oz. to the superficial yard and lightly rake in and consolidate.

Sow down with the undernoted mixture of grass seeds (or such other mixture as may be specially prescribed) at the rate of $1\frac{1}{2}$ oz. to the superficial yard. Seeds to be lightly raked in to give cover, pressed into the soil by a light roll, and left to strike.

The mixture:

		Origin	*Date of harvest*	*Purity*	*Germination*
40 per cent.	Chewings Fescue .				
40 ,,	Crested Dogstail .				
10 ,,	Poa pratensis .				
10 ,,	Agrostis tenuis .				

Percentages by weight.

Note. No peat, sand, or grit dressing should be applied to cricket wicket areas.

SECTION 8. *Grass Tennis Courts (Seeded)*

Levelling and soiling of these areas to be included for as may be necessary under Sections 2 and 3. The finished surface of the courts to have a crossfall not less than 1 in 120 or more than 1 in 60.

The preparation and seeding to be otherwise all as described for cricket squares except that where the soil is of a light permeable character a dressing of granulated peat should be incorporated as specified in Section 5.

SECTION 9. *Putting Greens*

Contouring or levelling as may be required to be included under Sections 2 and 3.

The preparation and seeding to be otherwise all as described for grass tennis courts, but seed mixture to be as follows:

	Origin	*Date of harvest*	*Purity*	*Germination*
80 per cent. Chewings Fescue .				
20 ,, Agrostis tenuis .				

Percentages by weight.

SECTION 10. *Turfing*

Areas to be turfed should be prepared, limed, and fertilized as before described, but turfed with a turf of approved quality. A typical sample of the turf to be submitted for approval along with a statement as to the source of supply so that this may be inspected, should the employers so desire, before bulk deliveries are commenced.

The turf field should be closely mown and rolled before lifting.

Turves to be cut to such convenient sizes as the contractor may determine most suitable for handling and transport with the minimum of breakage. Turves to be lifted to a uniform thickness of not less than 1½ inches and to be laid over the areas in rows transverse to the main direction of play and breaking joint in consecutive rows.

Turves to be laid with closely butted joints to correct levels without excessive beating. Any inequalities in finished levels owing to variation in turf thickness to be adjusted by raking out or packing in the soil below the turf as may be necessary to secure an even surface level of uniform consistency.

Areas are then to be lightly rolled with 4½-cwt. hand roller and the surface afterwards top dressed with a compost of sharp clean sand and fertilizer

(6 lb. of sand to 2 oz. of approved fertilizer per superficial yard). Application to be well distributed including filling all joints by means of drag brush or similar implement and the application lightly watered in should the climatic conditions require it.

Note. Any turfed areas to be used for cricket wickets shall be top dressed with a compost of Nottingham marl and fertilizer in place of sand and fertilizer specified. Proportions and rate of application as before described.

SECTION 11. *Maintenance*

The defects liability period in accordance with Clause 12 of the R.I.B.A. Conditions of Contract, shall be six months from certified date of completion for any works under Sections 1 to 10 where seeding or turfing is completed in the spring; nine months when completed in the autumn.

The contractor is to allow under this section for reseeding any bare areas with the mixture specified for the work, or returfing where the turf has failed to become established.

The contractor shall also provide for one application of fertilizer, mixed as described hereunder (or other approved), at a suitable time during the maintenance period:

Neutral sulphate of ammonia	1 part
Superphosphate	1 part
Muriate of potash	1 part

Rate of application 5 cwt. per acre.

The contractor will not be responsible for any routine maintenance work such as cutting, rolling, harrowing, &c., but shall furnish full instructions as to the extent and nature of such work to be carried out by the employers' ground staff during the defects liability period.

OTHER SPECIALIZED FACILITIES

SECTION 12. *Hard Tennis Courts*

Dimensions .....

Work to include:

1. *Clear Site*

Clear site of all vegetable matter and deposit in a convenient place agreed with the employers for use on other parts of the ground. Any suitable turf to be stripped and laid aside for use on external banks and surrounds.

2. *Level Site*

Excavate to take out formation level of courts maintaining a uniform crossfall of not less than 1 in 120 or more than 1 in 60. Excavated material to be wheeled and deposited where filling is required, put down in layers not exceeding 6 inches thick, well rammed between each layer and finally rolled to consolidate. Any surplus material to be transported and deposited where directed.

Note. The crossfall specified is to be maintained throughout the subsequent works of foundation, edging, and surfacing, although not specifically stated.

3. *Drainage*

A 4-inch diameter agricultural land drain to be laid diagonally from one high corner of enclosure to diagonally opposite low corner with inverts at a depth of not less than 15 inches below formation surface as blocked out, and collecting from feeder drains of 3-inch diameter agricultural land drains laid in rows parallel with sides of court on one side of the main drain, and in rows parallel with ends of court on the other side of the main drain to form a herring-bone system.

Feeder drains to be spaced as shown on drawings, with depths to invert at their highest point 6 inches below earth formation and a uniform fall towards the depth of the main drain at the point of intersection. Drains to be laid with closely butted joints to correct alignment, and drain trenches after pipes are laid to be filled to formation surface with clean boiler clinker ash, or broken stone, or shingle, 3 to $\frac{3}{4}$ inch gauge, carefully packed around and over pipes and thoroughly consolidated. The outfall from the lowest corner to be connected to nearest ditch, surface water drain, or to an adequate porous filled sump (not less than 5 cubic feet capacity per 100 superficial yards of surface). Capacity of sump to be measured below invert level of outfall drains.

Note. If preferred main drains may be laid around the courts 2 feet within boundaries with feeder drains in parallel rows with sides or ends. This method is advisable where there is a need to trap any seepage from adjoining areas.

The work to include all cutting of trenches and disposal of surplus excavations.

4. *Weed Prevention*

The earth formation as blocked out to be treated with chlorate of soda or other approved weed-killer as a precaution against weed or other vegetable

growths working upwards throughout the courts. The chlorate of soda to be dissolved at the rate of 1 lb. to 1 gallon of water and this amount applied to not more than 10 superficial yards of surface. Before applying the solution the surface should be well watered to promote more efficient penetration of the solution.

5. *Edging*

An edging to be provided round four sides of courts to ensure adequate lateral support. Edging should be of Blue Staffordshire Wirecut Bricks or equal, or approved pre-cast concrete edging not less than 2 inches thick. Edgings to be set to appropriate levels to finish flush with final surface levels, and to be bedded and well backed up in cement mortar (1 to 3).

6. *Foundation*

Foundation of courts to consist of a layer of clean boiler clinker ash or other approved dry filling, 3 to $\frac{3}{4}$ inch gauge, spread to a uniform depth of not less than $4\frac{1}{2}$ inches consolidated. Carefully levelled to correct gradients, and blinded with a layer of fine boiler clinker ash ($\frac{3}{4}$ inch to fine) screeded on to a depth of 1 inch consolidated. Foundation to be left with a smooth, uniform, well-bound finish to receive the surfacing.

Note. Certified delivery notes to be provided by the contractor to the employer's supervisor with each consignment, when requested to do so.

7. *Surfacing*

The surfacing shall be of an approved bituminous or tarred limestone to a consolidated depth of 2 inches applied in two layers as follows:

Undercoating. 1 to $\frac{3}{4}$ inch gauge material to a depth of $1\frac{1}{2}$ inches, the quantity of material used to be not less than 6 tons per 100 superficial yards.

Final Coating. $\frac{1}{4}$ to $\frac{1}{8}$ inch gauge material to a depth of $\frac{1}{2}$ inch, the quantity of material used to be not less than 2 tons per 100 superficial yards.

Carefully raked to proper levels and thoroughly consolidated to a uniform and well-bound surface.

Note. Certified delivery notes to be provided by the contractor to the employer's supervisor with each consignment, when requested to do so.

8. *Marking Out and Painting*

Temporary playing lines to be marked out on the black surface and after surface has weathered sufficiently (in no case less than 6 weeks) spray the surface twice with 'Bitulac' Grass Green Tennis Court Composition or other approved solution.

Thereafter the lines of courts to be marked out with two coats of approved white road line enamel or aluminium paint. Lines to be 1¼ inches in width except centre and base lines which must be 2 inches wide.

9. *Tennis Posts, Nets, and Adjusters*

Supply and fix the necessary tennis posts of approved type complete with chromium plated winders, best quality match nets, with copper top cord, steel cable ends, centre adjuster and fastener.

The contractor is to allow for adequate concrete foundation or other means to ensure secure fixing according to the type of post supplied.

Posts and nets included for to be specified hereunder:

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10. *External Banks and Verges*

The external banks round four sides of courts formed by cut and fill to be trimmed off to a slope not exceeding 1 in 1, covered with top-soil to a depth not less than 4 inches and turfed with suitable turf previously removed from site.

Where no turf is available banks to be seeded with a good recreation ground mixture including not more than 60 per cent. Short Seeded Perennial Rye Grass. Rate of sowing 1½ oz. to the superficial yard. Seeds to be lightly raked in to give cover and the surface lightly consolidated.

11. *Alternative Tennis Court Surfacing*

The contractor may quote for any alternative surfacing in which he specializes in addition to the foregoing specification stating any difference in price as a result of using his own material. Such quotation must be accompanied by a fully detailed specification of the type of surface and consolidated depth.

Whatever type of surface is quoted, the remaining work must be strictly in accordance with the foregoing specification.

SECTION 13. *Tennis Stop-net Fencing Surround*

Supply and erect around courts to lines as shown on drawings, stop-net enclosure 9 feet high above finished level of courts.

Corner and gate pillars 2½ by 2½ by ¼ inch angle steel with base plates

9 by 9 by $\frac{1}{4}$ inch set 2 ft. 6 in. into ground in Portland cement concrete 1 ft. 6 in. by 1 ft. 6 in. by 1 ft. 6 in. Corner and gate pillars to be fitted with struts of $1\frac{1}{2}$ by $1\frac{1}{2}$ by $\frac{1}{4}$ inch angles with base plates 6 by 6 by $\frac{1}{4}$ inch set 2 ft. 6 in. into ground in Portland cement concrete 1 by 1 by 1 foot. $1\frac{1}{2}$ by $\frac{1}{4}$ inch flat steel stiffening bar to be fitted between struts and posts.

Intermediate standards to be $1\frac{1}{2}$ by $1\frac{1}{2}$ by $\frac{3}{16}$ inch angles or tees with thrust plates, and driven 2 feet into ground and spaced not more than 10 feet apart, centre to centre. Gates to be supplied, and fixed in position shown, of angle steel framing with flat steel ties and braces, and fitted with slipbolt, padlock, and keys.

All covered with $1\frac{3}{4}$ inch mesh by 14 gauge galvanized interlinked diamond mesh netting supported on four rows of galvanized straining wire No. 8 gauge.

All ungalvanized materials to be painted, one coat before dispatch and two coats after erection, with a preservative preparation of approved colour.

Maintenance

The defects liability period for hard tennis courts shall be twelve months from certified date of completion, the contractor to supply complete notes as to any special attention to be given by the ground staff during this period.

SECTION 14. *Bowling Green (Flat Rink Game)*

Dimensions . . . . . exclusive of ditches, banks, verges, and surrounds.

Work to include:

1. *Clear Site*

Clear site of all vegetable matter or other rubbish and dispose of as may be directed by employers. Any suitable turf to be carefully stripped to convenient sizes; not less than 12 by 12 by $1\frac{1}{4}$ inches thick, and laid aside for re-use on external banks, verges, and surrounds.

2. *Level Sites*

After site has been cleared lay aside sufficient of the best vegetable soil (average depth 2 inches) for re-use in blinding mixture to formation.

Excavate to take out earth formation of green to true level. Excavated material to be wheeled and deposited where filling is required, put down in layers not exceeding 6 inches thick, well rammed and rolled after each layer, to ensure a well consolidated stable surface.

Any surplus material to be disposed of as directed by the employers.

3. *Worm Prevention*

As a precaution against worms or similar pests working upward through the green, the earth formation surface as blocked out to be treated with colloidal lead arsenate mixed at the rate of 2 lb. to a gallon of water and this quantity applied to every 25 superficial yards of area treated. The surface should be well sprayed with water immediately before applying the mixture to ensure more efficient penetration of the soil.

Alternative. If preferred, creosote oil may be applied, in place of the colloidal lead arsenate, at the rate of 1 gallon to every 10 superficial yards of formation surface. The surface should be well moistened before applying the creosote.

Where sites are very weedy and over-grown the creosote oil is to be preferred, where readily obtainable, as it also acts as a weed-killer.

4. *Drainage*

Four-inch diameter agricultural land drain tiles of best quality to be laid around four sides of green under the ditches. Pipes to be laid with closely butted joints with the highest point at one corner not less than 6 inches to invert below earth formation level of green as blocked out and graded with a uniform fall in both directions to a depth of 2 feet below earth formation level at the opposite diagonal corner. These drains to collect from 3-inch diameter agricultural land drains spaced 18 feet apart in rows parallel to the diagonal fall of the ditch drains, and commencing 10 feet from the ditch where the highest points must not be less than 6 inches to invert. These drains to have a uniform fall to the point of intersection at invert level of ditch drains.

Trenches to be cut as narrow as possible for convenience in laying pipes and drain excavations to be disposed of as may be directed. Trenches after pipes are laid and approved, to be filled to formation surface with clean boiler clinker, or other approved dry filling, broken to 3 to $\frac{3}{4}$ inch gauge, carefully packed around and over pipes and well consolidated.

The outfall from the lowest point to be connected to nearest surface water drain, ditch, or to an adequate porous filled sump (not less than 5 cubic feet capacity per 100 superficial yards of surface). Capacity of sump to be measured below invert level of outfall drain.

5. *Ditches*

Ditches 12 inches wide to be formed round four sides of green of 6 by $1\frac{1}{4}$ inches sawn deal boarding in 10 foot lengths. Inner ditch board to be set

¼ inch below finished turf level for turfed greens, or at finished soil level in the case of seeded greens. Outer ditch board should be set approximately 1½ inches above level of inner board. Ditch boards to be fixed to 3 by 1½ by 18 inches long pegs pointed and driven into ground at centres not exceeding 5 feet apart. Corner pegs to be 3 by 3 by 30 inches. Boards set to correct levels and perfect alignment and braced apart at 5 foot centres with 3 by 1¼ inches sawn deal struts 12 inches long.

All timber to be thoroughly creosoted under pressure.

The ditches formed by the boarding to be filled with clinker or other approved filling as described for drains and topped with a layer of round beach pebbles (1¼ to ¾ inch gauge). The top of the pebbles to finish 1½ inches below level of green.

Alternative. As timber may not be obtainable, the formation of the ditches in pre-cast concrete may be carried out as follows:

Outer and inner sides of ditches to be of 6 by 2 inches pre-cast concrete kerb with top edge bevelled at 45 degrees. Kerbs to be set on edge to proper alignment and to true levels on 6 by 3 inches Portland cement concrete foundations. The deeper sides of kerbs to face the ditch with the turf of green and banks finishing against the bevel. Kerbs to be faced up from edge of concrete foundation to half-way up each side in cement mortar to resist overturning. Inner kerbing to be set to finish flush with turfed level of green. Outer kerbing to be set 1½ inches below level of inner kerbing so as to finish flush with pebble covering to clinker filling of ditches. Otherwise all as before described.

6. *Foundation*

The foundation of the green to consist of a layer of clean boiler clinker (3 to ¾ inch gauge) spread over area of green to a depth of 4½ inches consolidated. Carefully levelled and consolidated and covered with a layer of clean clinker ash (½ inch to fine) well mixed with an equal quantity of good vegetable top-soil (through ½-inch screen) and spread and levelled to a consolidated depth of 3 inches.

7. *Turfing*

The playing area of the green to be treated with pulverized peat (Humull or other approved) mixed with suitable approved lawn fertilizer in the proportion of 4 oz. of peat to 2 oz. of fertilizer applied to every square yard of surface and well raked in.

Turf to be selected sea-washed turf, or approved moorland or hill turf, of

suitable quality, samples to be submitted before dispatch, and source of supply to be stated so that turf may be inspected in its natural state if desired. (*Note.* Turf to be closely mown and prepared before lifting.) Turves to be cut in 12-inch squares and boxed to a uniform thickness of $1\frac{1}{4}$ inches, and to be laid in diagonal courses over the playing area of the green bedded direct on the prepared foundation. Accurate finished levels to be maintained by raking out or packing in below the turf as may be required and not by excessive beating. Turves to be merely lightly tapped to ensure a firm bedding with the soil. No broken or torn turves to be used and turves to break joint in consecutive rows.

After turfing is completed a light roll may be given when the turf is fairly dry and the surface thereafter dragged over lightly with the drag brush and top dressed with a compost of sharp washed sand mixed with powdered vegetable charcoal and approved lawn fertilizer in the proportion of 6 lb. sand, 6 oz. charcoal, and 2 oz. fertilizer applied to every superficial yard of surface evenly distributed by lightly brushing, taking care to work well into joints, and leave turf to strike.

Note. No work to be carried out, when turfing stage has been reached, if turf is in a saturated or frost-bound condition.

8. *Banks and Verges*

Banks to be formed round four sides of the green not less than 12 inches high above playing surface. Banks to be formed to a slope not greater than 2 in 1, and to have 12-inch wide verges along the top of the banks and at the outer edges of the walks along the top of the banks. Banks and verges to be formed with the best of the soil from excavations and turfed with turf equal in all respects to that specified for the playing area of the green but bedded direct on to the soil and the turves on the face of the bank to be pegged to the soil with wooden skewers until turf has rooted.

9. *Roller Recess*

A recess for roller to be provided in some convenient corner of green measuring 3 ft. 6 in. by 3 ft. 6 in. bottomed with clinker and covered with pebbles as described for ditches and finishing level with top of ditch pebbles. Recess to be formed on external sides with banks and verges as before described.

10. *Walks*

Walks to be provided, round four sides of green along the top of the banks

..... wide. Walks to be bottomed with mixed boiler clinker to a consolidated depth of 4½ inches with a cambered formation, well blinded with fine ash and surfaced with two coats of tar macadam of approved quality to a consolidated depth of 2 inches. Edging to both sides of walks to be of 6 by 2 inches pre-cast concrete kerbing finished level with sides of walks and bedded, jointed, and backed up in cement mortar.

11. *Nursery*

A nursery to be provided on some convenient section of the surrounds containing not less than 20 superficial yards of turf similar in all respects to that used for the playing area of the green and laid on a foundation as before described.

12. *External Banks*

External banks beyond outside of walks as formed by the cut and fill to be trimmed off to a slope of not more than 1 in 1, soiled and left for planting, or turfed with any turf previously removed from site. Before commencing the slope there should be a 12-inch wide turf verge along the outer edge of the walks.

13. *Maintenance*

The contractor shall on completion of the work instruct the employer's groundsman on the steps to be taken in working up the green during the maintenance period, which shall be six or nine months from certified date of completion, according to season.

SECTION 15. *Alternative for Dwarf Wall to Bowling Green in place of Turfed Banks and Verges*

Note. Turfed banks are extremely difficult to maintain in good condition and where materials are available the following alternative will give much more permanent satisfaction and will save the labour which would otherwise be expended in trying to maintain the grass banks:

Provide on external side of ditch 4½-inch brick wall of good-quality facing bricks in cement mortar and finished with neatly struck joints. Foundation of wall to be 9 by 4½ inches Portland cement concrete with top level with bottom of clinker foundation to green. Top of wall to finish flush with inner edge of walks round green at a height of 12 inches above turfed level of green.

Where timber is available, the face of the wall should have three 3 by 1½ inches creosoted deal slats running in parallel rows with top of wall and

spaced 1½ inches apart with bevelled upper edges. These slats firmly fixed to wall by countersunk screws, are to protect over-running woods from damage.

Where timber is not available sufficient coco-nut matting should be provided 2 feet wide to drape over face of wall as a protection.

Where dwarf walls are provided the outer edging to ditch will not be necessary, but where timber edging is used for the green it should be braced at 5-foot centres from the face of wall by 3 by 1¼ inches creosoted sawn deal struts as before specified. Otherwise all as before described.

SECTION 16. *Sown Bowling Green*

The contractor is to quote for sown green including formation, worm prevention, drainage, ditches, and foundation all as before described but in place of fine ash and soil layer, the coarse clinker layer to be topped with a layer of good vegetable loam free from stones and spread and levelled to a consolidated depth not less than 4 inches to finish flush with top of inner ditch board.

Top dress with approved lawn fertilizer at the rate of 2 oz. to the superficial yard, powdered vegetable charcoal at the rate of 4 oz. to the superficial yard, and pulverized peat at the rate of 1 lb. to the superficial yard. These dressings to be thoroughly worked into the soil by raking after which the surface should be carefully levelled off and lightly rolled with an elm roller.

At a suitable time thereafter sow down the area with the undernoted mixture of grass seed at the rate of 2 oz. to the superficial yard:

	Origin	*Date of harvest*	*Purity*	*Germination*
80 per cent. Chewings Fescue .				
20 „ Agrostis tenuis .				

Every care should be taken to ensure even distribution. Seeds to be lightly raked in to give cover or covered with sifted soil to a depth not exceeding ¼ inch. The surface to be finally lightly rolled and seeds left to strike.

Otherwise all as described for turfed bowling greens but banks and verges of seeded greens to be turfed with selected meadow turf, or any suitable turf previously removed from site.

SECTION 17. *Crown Bowling Green*

Dimensions 40 by 40 yards exclusive of ditches and surrounds.

Work to include:

1. *Clear Site*

Clear site of all vegetable matter and other rubbish and dispose of as may be directed by employers. Any suitable turf to be carefully stripped to convenient sizes—not less than 12 by 12 by $1\frac{1}{4}$ inches thick—and laid aside for re-use on surrounds.

2. *Strip Soil*

Strip top-soil approximately 3 inches deep from area of green and lay aside for re-use.

3. *Shaping Formation*

Excavate where necessary to take out formation of green to camber as described hereunder:

Level of crown at centre of green to be 10 inches above corner levels. From centre set out circles at 10, 20, 30, 40, 50, and 60 feet radii. The height of the contours on these circles will be respectively $9\frac{3}{4}$, $9\frac{1}{4}$, $8\frac{1}{2}$, $7\frac{1}{2}$, $6\frac{1}{2}$, and 5 inches above the level at corners. This camber formation is to be maintained throughout each constructional phase from the foundation to finished turfed surface, the levels being graded uniformly between consecutive circular contours and between the final contour and the corners. The edge of the ditch will therefore be graded uniformly from zero at the corners to 5 inches at centre of each side.

Excavated materials to be wheeled and deposited where filling is required, put down in layers and thoroughly consolidated. Any surplus material to be disposed of as directed by the employers.

4. *Drainage*

The drainage of the green to consist of a 4-inch diameter agricultural land drain round four sides of the green under the ditches, with the highest point approximately 6 inches below earth formation to invert at one corner and graded uniformly in both directions to a depth of 2 feet below earth formation at the opposite diagonal corner from which the outfall must be connected to nearest surface-water drain, ditch, or to an adequate porous filled sump of not less than 6 cubic feet capacity per 100 superficial yards of surface. Capacity of sump to be measured below invert level of outfall drain.

Drains to be of best quality, hard, well burnt, and true to bore and to be laid with closely butted joints carefully packed around and over the pipes with clean boiler clinker, broken stone, shingle, or other approved dry

filling, broken to 3 to $\frac{3}{4}$ inch gauge, brought up to formation surface and thoroughly consolidated.

5. *Ditches*

The ditches to be formed of 6 by $1\frac{1}{4}$ inch sawn deal boarding in 10-foot lengths. The inner edge of ditch to consist of a single board set to proper rake to suit camber of green. The outer edge of ditch to consist of two 6 by $1\frac{1}{4}$ inch boards one above the other with the uppermost edge set to a uniform level 6 inches above corner levels of green. Boards to be set to proper alignment and levels and securely fixed to 3 by $1\frac{1}{2}$ inch pegs, 2 feet long, and pointed and driven into ground at 5-foot centres. Outer and inner boarding to be braced apart at 5-foot centres by 3 by $1\frac{1}{4}$ inch sawn deal struts 12 feet long. Corner pegs to be 3 by 3 by 30 inches long.

All timber to be thoroughly creosoted under pressure.

The ditches formed by the boarding to be filled with clinker or other approved filling, as described for drains, covered with a layer of round beach pebbles ($1\frac{1}{4}$ to $\frac{3}{4}$ inch gauge). Top of pebbles to finish $1\frac{1}{2}$ inches below turfed level.

Alternative. As timber may not be obtainable, the formation of the ditches in pre-cast concrete may be carried out as follows:

Inner side of ditch to be of 6 by 2 inches pre-cast concrete kerb with top edge bevelled at 45 degrees for edge of turf to be sloped and finished flush with outer edge of kerb. Outer side of ditch to be of 12 by 2 inches pre-cast concrete kerb, with squared edges. Kerbs to be laid to proper alignments and to levels as described for timber edging, on 6 by 3 inch Portland cement concrete foundations. Kerbs to be faced up from edge of concrete foundation to half-way up each side in cement mortar to resist over-turning.

Otherwise ditches all as before described.

6. *Worm Prevention*

As a precaution against worms or similar pests working upwards through the green, the earth formation surface as blocked out to be treated with colloidal lead arsenate mixed at the rate of 2 lb. to a gallon of water, and this quantity applied to every 25 superficial yards of area treated. The surface should be well sprayed with water immediately before applying the mixture to ensure more efficient penetration of the soil.

Alternative. If preferred, creosote oil may be supplied in place of the colloidal lead arsenate, at the rate of 1 gallon to every 10 superficial yards of

formation surface. The surface should be well moistened before applying the creosote.

Where sites are very weedy and overgrown, the creosote oil is to be preferred, where readily obtainable, as it acts also as a weed-killer.

7. *Foundation*

The foundation to consist of a layer of boiler clinker or other suitable dry filling broken to 3 to $\frac{3}{4}$ inch gauge and spread to a uniform depth of $4\frac{1}{2}$ inches consolidated over the playing area, maintaining the camber before described. This layer to be covered with a layer of fine boiler clinker ash ($\frac{1}{2}$ inch to fine) mixed with an equal proportion of riddled top-soil and spread to a uniform consolidated depth of not less than 4 inches maintaining the camber before described.

Dress the surface with approved lawn fertilizer at the rate of 2 oz. to the superficial yard; pulverized peat at the rate of 1 lb. to the superficial yard and well rake into surface, re-shape to camber as described and lightly roll.

8. *Turfing*

Turf green with selected turf (sea-washed, hill, or other approved). Sample to be submitted for approval and source of supply stated. Turf to be closely mown and prepared before lifting. Turves to be cut in 12-inch squares and boxed to a uniform thickness of $1\frac{1}{4}$ inches, and to be laid in parallel rows over the area of the green maintaining the finished camber. Any inequalities to be adjusted by raking out or packing in the formation below the turf and not by excessive beating. Turves to be laid with closely butted joints breaking joints in consecutive rows and lightly tamped to ensure a firm bed.

After turfing, the green to be top dressed with approved fertilizer, powdered vegetable charcoal, and sand mixed in the proportions of 2 oz. fertilizer, 6 oz. charcoal, and 6 lb. of sharp sand applied to every superficial yard of the surface. Evenly distribute by dragging over with drag brush and working into joints as the dressing proceeds, and leave turf to strike.

9. *Walks*

Provide walks ... wide round four sides of green, slightly cambered to give watershed and with inner-edge level with outside ditch-board. Paths to be formed of a layer of boiler clinker, $4\frac{1}{2}$ inches consolidated, raked to proper camber, and surfaced with two coats tar macadam of approved quality to a consolidated depth of 2 inches. The outside edge of walk to be supported by 4 by 1 inch creosoted timber edging on 2 by 2 inch pegs, 15 inches long, pointed

and driven into ground at 4-foot centres, or approved pre-cast concrete edging, bedded, jointed, and backed up in cement mortar.

10. *External Banks*

External banks, formed by the cut and fill, to be dressed off to a slope not exceeding 1 in 1, dug over, soiled, and left ready for planting, or turfed with any turf previously laid aside. Before commencing the slope there should be a 12-inch wide verge along outer edge of walks.

11. *Nursery*

A nursery to be provided on some convenient site adjacent to the green containing 20 superficial yards of turf as laid on the playing area, put down on a level clinker and soil foundation, otherwise all as before described.

12. *Maintenance*

The contractor shall, on completion of the work, instruct the employer's groundsman on the steps to be taken in working up the green during the maintenance period which shall be six or nine months from the certified date of completion, according to season.

SECTION 18. *Athletic Facilities—Running Tracks*

Tracks to be set out to the lines shown on the drawings.

Note. It is important that, wherever possible, the track should be constructed dead level. Where for economic or other reasons this is impracticable a gradient of 1 in 60 may be permissible provided the straight sections of the track are transverse to the direction of the fall.

Work to include:

1. *Clear Site*

Clear site of all vegetable matter, or other rubbish, and cart away or otherwise dispose of as may be directed.

2. *Excavations*

Excavate average 14 inches deep to take out formation of track to a uniform level, and cart away surplus, or otherwise dispose of as may be directed. Well roll excavated surface to a smooth, firm, and uniform level.

3. *Drainage*

Provide drainage to track by means of 4-inch diameter agricultural land tile drains laid just inside each edge of track. Drains at their highest point to be not less than 1 foot to invert below earth formation as blocked out at the

centre of each curved end, and with a uniform fall in each direction to a depth of 2 ft. 6 in. below formation level at the centre of each straight from which points connexions to be made to nearest convenient surface-water drain, or adequate porous filled sump of a capacity of not less than 6 cubic feet per 100 superficial yards of track surface. The capacity of sump to be measured below invert level of outfall drain.

Drains to be of best quality, hard, well burnt, and true to bore and to be laid with closely butted joints to correct alignment and grade. Trenches to be cut as narrow as possible consistent with the efficient placing of the pipes. After pipes are laid trenches to be back filled with hard, clean, boiler clinker, broken stone, shingle, or other approved dry filling (3 to $\frac{3}{4}$ inch gauge), carefully packed around and over pipes, brought up to level of formation surface, and thoroughly consolidated. Dispose of surplus excavations as may be directed.

4. *Edging*

Provide and fix to edges of track approved pre-cast concrete edging 6 by 2 inches, firmly bedded and backed up on Portland cement concrete 4 inches thick. Edging to be set to accurate alignment and levels, and to finish 2 inches above final levels of track.

5. *Weed Prevention*

As a prevention against weeds and other vegetable growths working upward through the track surface, the earth formation to be treated with chlorate of soda 1 lb. to a gallon of water applied to every 10 superficial yards of formation area. Every care to be taken to ensure even treatment on the entire area. Before applying the solution the surface should first be well moistened with water just before application of weed-killer to promote a more efficient penetration.

6. *Track Formation*

The foundation of the track to consist of a layer of clean boiler clinker ash, broken to pass 3-inch mesh and to be retained on $\frac{3}{4}$-inch mesh, evenly spread over the earth formation to a uniform consolidated depth of $4\frac{1}{2}$ inches, and blinded with a layer of screened clinker $\frac{3}{4}$ to $\frac{1}{2}$ inch gauge spread to a consolidated depth of $3\frac{1}{2}$ inches. Consolidation to be effected by means of 5-cwt. roller until a firm surface is obtained, any hollows showing after rolling each layer to be made good with fine material to ensure a true level surface before proceeding with the next layer.

For the next layer the fine clinker ash must be screened through a ¼-inch mesh and mixed with riddled clay or marl and fine washed sand in the proportion of 1 cubic yard of clinker ash, 4 cubic feet of clay, and 2½ cubic feet of sand, preferably in a mechanical mixer, with just sufficient water to make it plastic and workable. Before applying this mixture, the surface of the previous clinker layer should be lightly loosened by scarifying to a depth of not exceeding 1 inch, and well watered. The mixed material is then to be screeded on to accurate levels to give a depth after consolidation of 3 inches. The surface is then to be repeatedly watered, brushed, and rolled with 15-cwt. roller until the desired consistency is obtained.

The final layer to consist of a mixture of fine clinker ash screened through ¼-inch mesh and mixed with riddled clay and fine washed sand as before described but in the proportion of 1 cubic yard of cinders, 2 cubic feet of clay, and 1 cubic foot of sand, the application to be made by screeding to give a consolidated depth of 1 inch after lightly scarifying and watering the previous layer as before described.

Finally water, brush, and roll, with 15-cwt. roller to a well-bound surface, and after approval, spray with a concentrated solution of chlorate of soda as before described or other approved weed-killer.

Alternative Method of Track Surfacing

After completing the coarse and fine clinker layers, as before described, to a total consolidated depth of 8 inches, the finishing to be applied as follows:

Lightly scarify clinker surface and water, as before described, and screed over a depth of 2½ inches fine sharp clinker ash (¼ inch to fine gauge) and lightly roll. Cover with a layer of sifted clay to a depth ¾ inch and lightly roll. Apply sand to a depth of ¼ inch and thoroughly blend the fine clinker, clay, and sand by repeated harrowings, raking, watering, brushing, and rolling (preferably with a Sheep's Foot roller), to a uniform texture and consistency; lightly scarify and wet surface and apply a further layer of fine ash to a depth of 2½ inches, cover with ¼ inch of clay and lightly roll. Apply sand ⅛ inch, watering, brushing, and rolling, as before described, to produce a hard, well-bound surface.

Finally spray surface with weed-killer, as before described.

Note. As the desired consistency will be largely dependent on the quality of the ingredients used in the surfacing layers the final applications may have to be varied slightly, and the contractor shall therefore quote for any additional applications as under:

Apply fine sharp clinker ash (through ¼-inch screen) to a depth of ¼ inch and well roll twice, water, brush, and roll three times.

At the rate of ..... per superficial yard.

Apply finely riddled clay to a depth of ¼ inch and well roll twice, water, brush, and roll three times.

At the rate of ..... per superficial yard.

Run-ups for long jump, high jump, pole vault; and bases for hammer throw, discus, and putting the weight should be constructed in a similar manner to that described for the track.

Run-ups to pole vault and long jumps should not be less than 4 feet wide and 126 feet long.

Run-up to high jump should be semicircular area of not less than 50-feet radius from the mid-point between uprights.

Jumping Pits: High jump, not less than 12 by 12 feet. Pole vault, not less than 12 by 15 feet. Long jump, not less than 9 by 30 feet, with take-off board 8 by 4 inches, painted white, and set flush with take-off surface at a distance of 30 inches from edge of pit.

The ground between take-off board and edge of pit to be sanded to a depth of ½ inch.

Pits should be excavated to a depth of not less than 1 ft. 9 in. below the level of the take-off for long jump and high jump, and 2 ft. 4 in. below the level of the take-off for the pole vault, and an outlet drain should be provided linking up with the subsoil drainage system where necessary.

Pits should be bottomed with a layer of mixed boiler clinker to a depth of 4½ inches and the remainder of the depth loosely filled to the surface with clean, washed, sharp sand, or a mixture of sharp, washed sand and finely chopped straw, or sawdust, in the proportion of 4 to 1.

SECTION 19. *Children's Playgrounds*

General grass area to be constructed in accordance with specifications laid down in Sections 1 to 6 as far as may be applicable.

The dry surface area where shown to be cleared of vegetable matter, levelled, and drained as may be required, treated with chlorate of soda or other approved weed-killer, and bottomed with a layer of clean boiler clinker, broken brick, or other approved hardcore, 3 to ¾ inch gauge, to a consolidated depth of not less than 4½ inches.

Blind well with fine stuff to true levels, water if necessary and roll.

Surface with 'Redgra', or other approved crushed stone or blinding gravel,

put down in two layers to a consolidated thickness not less than 1½ inches. Undercoating to be of ¾ to ¼ inch gauge material to a depth of 1¼ inches consolidated.

Well watered, rolled, and finally dusted over with ¼ inch to fine material, watered in, brushed, and rolled as may be necessary to produce a firm, smooth, well-bound surface of the required thickness.

Supply and erect the playground equipment as indicated on the drawings. The allowance for circulation between the safety-clearance areas, as recommended by makers, to be not less than 10 feet in width except where apparatus adjoins the boundaries where the allowance should be 6 feet in width.

The erection to include all excavation, disposal of surplus, and firmly fixing in Portland cement concrete foundations of adequate proportions and strength as laid down by manufacturers, and making good any damage to surface caused by erection.

All iron work to be painted one coat before and two coats after erection with a suitable protective paint of approved colour.

Alternative Surfacing

An alternative price should be stated for children's playground, all as before described, but in place of crushed stone, or other water-bound surfacing, the dry playground to be surfaced with approved tar macadam put down in two coats to a consolidated thickness of 2 inches, well blinded with limestone or other approved stone dust, and rolled to a hard, well-bound surface.

A suitable edging to provide lateral support to the edges of the surfacing to be provided to all dry-surface areas of whatever type similar to the edging as described for hard tennis courts. If preferred and obtainable an edging of sawn-deal boarding, 4 by 1 inch, securely fixed to 2 by 2 inch pegs, 15 inches long, spaced 4 feet apart, and driven into ground, may be substituted in place of brick or concrete edging. In such a case all timber must be creosoted under pressure.

Note. Where the general area of the playground is constructed of 'Redgra', or other water-bound type of surface, it is recommended that the safety-clearance areas beneath the various pieces of equipment should be specified in tar macadam, as above.

SECTION 20. *Water-supply*

The contractor shall pay all fees necessary for connexion to public mains and installation of meter. Provide water-meter chamber of brickwork in cement mortar with Portland cement concrete foundation and approved

covers. Excavate trenches not less than 2 ft. 6 in. deep and provide and lay pipes of the sizes indicated with all necessary fittings and including a drain-off stopcock at the lower end of all sections with connexion to a soakaway so that the water may be turned off and the system emptied during periods of severe frost. Hydrants to be fitted convenient to those facilities where shown, and enclosed in cast-iron surface boxes with hinged covers. No hydrant to be less than $\frac{3}{4}$-inch diameter and to be of the bayonet coupling type.

The whole work as regards quality and diameter of piping and method of laying to be strictly in accordance with the regulations of the local water board or company and shall be approved by them.

The work to include refilling of trenches after pipes have been tested and making good all surfaces where disturbed.

SECTION 21. *Asphalt Cycle Track*

1. *Preparation of Formation*

Set out track to the dimensions as indicated on the drawings.

Clear site of all vegetable matter, or other rubbish, and remove from ground.

Excavate where necessary to obtain the required levels and to ensure a stable formation and dispose of surplus.

Provide embanked formation of track to finished profiles as indicated on the drawings.

All filling must be good clean, hard, dry filling of approved quality, deposited in layers not exceeding 6 inches thick, and well rolled and consolidated after each layer and finally trimmed off to required gradients as shown.

Provide 6 by 2 inch pre-cast concrete edging to both edges of track, bedded on and backed up with Portland cement concrete, 4 inches thick. Top of edging set to finish flush with final surface levels of track.

Provide foundation layer for surfacing of clean boiler clinker 3 to $\frac{3}{4}$ inch gauge spread to a uniform depth and well consolidated to 6 inches by motor-roller. Blind with slag or binding gravel ($\frac{3}{4}$ inch to fine gauge) to a depth of 1 inch and well roll to consolidate, making good any depressions showing after rolling with additional fine slag or gravel and roll to a firm, true, and uniform surface to the gradients indicated.

2. *Surfacing*

When the foregoing work has been approved, provide surfacing as under;

Undercoating. Approved tarred limestone (1 inch to fine) laid in one coat to a depth of 1½ inches consolidated. Quantity of materials used to be not less than 6 tons per 100 yards superficial. Spread and consolidate to a uniform thickness maintaining the gradient specified.

Final Surfacing. Apply tack coat of approved bituminous emulsion and provide and lay 'Carpave' or other approved asphalt fine topping to a depth of ½ inch consolidated in accordance with maker's instructions. The quantity used to be not less than 2 tons per 100 yards superficial. Carefully spread to a uniform thickness, maintaining the gradients indicated, and well rolled to a well-bound firm surface.

3. *External Banks* (where no spectators' terracing is provided):

External banks on outside of track to be trimmed off to a batter not exceeding 1 in 1, soiled to a depth of 6 inches with suitable soil previously removed from site and sown down with grass seed at the rate of 2 oz. to the superficial yard.

SECTION 22. *Concrete Cycle Tracks*

1. *Preparation of Formation*

All as before described for asphalt track-edging and foundation-layer as item (1) of previous specification.

2. *Concrete Surfacing*

Materials:

Cement. The cement used shall be of British manufacture and shall comply with the requirements of the British Standards Institution.

Suitable provision for storage and protection from moisture and atmospheric influences shall be provided by the contractor.

Sand. To be clean, hard sand, or crushed stone screenings free from dust, loam, clay, or vegetable matter. All particles shall pass a $\frac{3}{16}$-inch sieve and shall be uniformly graded with not more than 20 per cent. passing a sieve having fifty meshes per lineal inch.

Should a finer material than that specified be submitted for approval, its use will be approved only on condition that the cement content is increased to give the same strength as would be obtained with a sand which complies with the above specified grading.

Stone. This shall be approved gravel or crushed stone graded from $\frac{3}{4}$ to $\frac{3}{16}$ inch, free from dust, clay, or organic matter.

Voids in aggregate. Tests may be made as and when required by the archi-

tect or engineer to ascertain the voids in the coarse aggregate and the bulking of the sand due to moisture. The proportions of the aggregate shall be adjusted to give the most satisfactory mix. Alternatively to the voids test, the architect or engineer may direct that a mechanical analysis shall be made of the aggregate and the proportions adjusted as directed.

Water. Only fresh clean water from the water mains or from a source approved by the architect or engineer shall be used for mixing purposes.

Concrete proportions. Subject to any adjustments considered necessary after the void tests have been made, the proportions assuming damp sand (30 per cent. bulked) shall be as follows:

1 cwt. cement.
$3\frac{3}{4}$ cubic feet sand (damp).
5 cubic feet coarse aggregate.

Gauging, mixing, placing, and finishing concrete. All materials shall be accurately measured in suitable gauge boxes. The cement shall be measured by weight, assuming the following:

1 cubic foot ordinary cement (loose) weight 90 lb.
1 bag of cement weight 1 cwt. = $1\frac{1}{4}$ cubic feet (approx.).

Rapid hardening cement:
1 cubic foot cement (loose) weight 80 lb.
1 bag cement (1 cwt.) = 1·4 cubic feet.

Mixing. Concrete shall be mixed in a mixer of approved type. No mix shall leave the machine unless obviously properly mixed and of a medium consistency. No concrete shall be mixed or placed in frosty weather.

The minimum amount of water shall be used in the mix consistent with workability. Where the track is superelevated at the curves, the contractor shall be responsible that the concrete shall be of such consistency that it will not flow or creep when placed or when being tamped.

Placing or tamping. The concrete shall be placed over a layer of tarred paper and tamped as rapidly as possible after being mixed, and the surface shall be finished within forty minutes of the commencement of mixing. The concrete shall be tamped to proper consolidation. All concrete placed against formwork shall be sliced against same in order to produce a close knit surface.

Finishing surface. The surface shall be finished with a smoothing board and immediately afterwards checked with a 10-foot straight edge. Any differences of level exceeding $\frac{1}{4}$ inch shall be at once rectified.

Mechanical tamping. As an alternative to the above, a mechanically

vibrated tamper may be used for consolidating and finishing the surface, but the same accuracy of finish must be obtained.

Joints. The concrete track shall be constructed in alternative bays or panels not exceeding 15 feet in length. The intervening bays or panels to be made after previous bays have set.

All the joints between the bays shall be vertical butt joints extending the full depth of the slab. All joints shall be provided with ¾-inch diameter mild steel dowel bars 2 ft. 6 in. long spaced at 24-inch centres. These bars shall be set at half the depth of the slab, one-half of the bar being in each adjoining slab. One-half of each dowel bar shall be wrapped in tarred paper or other approved means adopted to prevent adhesion to the concrete on one side of the joint. At the end of this half provision shall be made for expansion of the bar. The ends of the bars on the other side of the joint shall be firmly embedded in the concrete of the adjacent slab.

Curing. Immediately after completion of the surface, it shall be covered with waterproof paper securely held in position so that it is in contact with the surface. This curing to be continued for nine days.

Alternatively, the surface may be protected by canvas or hessian which shall be kept in position for twenty-four hours. Thereafter the surface may be covered with sand or earth which shall be kept damp for a further eight days at least, after which it shall be swept off and removed.

SECTION 23. *Dry-surface Playing Pitches*

Dimensions ..... exclusive of banks and surrounds.

Strip site of all vegetable matter and other detrimental rubbish and burn or otherwise dispose of as may be directed.

Excavate to take out formation level of pitch. Excavated material to be wheeled and deposited where filling is required, put down in layers not exceeding 6 inches thick, and thoroughly consolidated. External slopes of the cut and fill to be trimmed off to uniform gradients not exceeding 1 in 1, covered with 4 inches (consolidated depth) of the best of the top-soil from the excavations, and sown down with a suitable recreation ground mixture of grass seed at the rate of 1 oz. per superficial yard.

Any surplus excavations to be disposed of as may be directed by the employers.

The formation as blocked out to be drained by means of land drains to the lines, sizes, and depths as shown on drawings. Pipes to be of best quality, hard, well burnt, and true to bore, and to be laid in trenches to proper

alignment with closely butted joints. After pipes are laid, trenches to be filled to formation surface with mixed clinker and ashes, carefully packed around and over pipes, and thoroughly consolidated. Surplus excavations from the drain trenches to be disposed of as may be directed.

Provide edging round four sides of pitch of 6 by 2 inch pre-cast concrete edging on 6 by 3 inch Portland cement concrete foundation. Edging to be haunched up from each edge of foundation to half-way up each side and jointed in cement mortar.

The earth formation as blocked out to be treated with chlorate of soda, 1 lb. to a gallon of water applied to every 10 superficial yards of formation surface which must be well moistened with water just before application of weed-killer to promote more efficient penetration.

The foundation of the pitch to be formed of a layer of boiler clinker (3 to $\frac{3}{4}$ inch gauge) spread to an even depth and well blinded with fine clinker ash ($\frac{3}{4}$ inch to fine). The total consolidated depth of foundation to be not less than $4\frac{1}{2}$ inches. Any inequalities showing after rolling to be made good with additional fine ash until a firm true surface is obtained.

The final surface to be formed of 'Redgra' or other approved crushed rock or binding gravel ($\frac{3}{4}$ to $\frac{1}{4}$ inch gauge) spread to a uniform depth of $1\frac{1}{4}$ inches well watered, rolled, and consolidated. Blinded with fine material of similar quality ($\frac{1}{4}$ inch to fine) applied in several dustings and well watered, brushed, and rolled to form a hard, well bound, level surface. The total consolidated depth of completed surface to be not less than $1\frac{1}{2}$ inches.

SECTION 24. *Concrete Cricket Wickets*

Dimensions as shown on drawings.

Work to include:

Excavate to an average depth of 9 inches to take out formation level of wicket. Surplus excavations to be disposed of as may be directed by the employers.

Formation surface as blocked out to be treated with 10 per cent. solution of chlorate of soda applied at the rate of 1 gallon to every 10 superficial yards of surface. The surface to be well watered just before applying this weed-killer to ensure good penetration.

Foundation to consist of a layer of broken brick, gravel, clinker, or other approved hardcore (3 to $\frac{3}{4}$ inch gauge) spread uniformly over the area to proper levels and well blinded with fine stuff to a consolidated depth of 4 inches.

The hardcore foundation to be covered with a layer of waterproof paper of approved quality. Any joints in the paper to be lapped at least 3 inches. Where waterproof paper is not available, hardcore foundation to be well wetted immediately before placing concrete.

The concrete to be mixed in the following proportions:

1 part cement.

2½ parts sharp washed sand.

4 parts ¾ to ¼ inch approved crushed stone aggregate.

This should be thoroughly well mixed with just sufficient clean water to make the mixture workable and screeded over the area to a depth of 5 inches with a layer of No. 14 B.R.C. Fabric or other approved reinforcement set 2 inches from bottom of slab. Concrete to be screeded to proper levels and trowelled to a smooth accurate surface. Where no reinforcement is provided the wicket shall be concreted in three sections finished with vertical ends, the centre slab being placed last after the end sections have set.

Provide clay-box for stumps of 6 by 1 inch creosoted boarding, over-all dimensions 12 by 6 inches. Box to be set flush with level of concrete wicket and to be filled with clay well consolidated.

Bowlers run when required should be at least 18 feet long beyond the stumps and with a width as shown. The area should be excavated to a depth of 6 inches, surplus excavations being disposed of as directed.

The foundation of the run to consist of a layer of boiler clinker (3 to ¾ inch gauge) spread uniformly over the area to correct levels, well blinded with fine stuff, watered if necessary, and consolidated to a depth of 4 inches.

The surfacing to be of 'Redgra' or other approved crushed stone material, screeded to correct levels, watered, and well rolled to a consolidated depth of 2 inches, or preferably the surface may be finished in tar macadam.

SECTION 25. *Bowling Lawn or Croquet Lawn*

Dimensions .....

Note. Where for economic reasons the standard method of bowling green construction cannot be faced and a level lawn will suffice where woods may be thrown in informal games, it is advisable to provide walks round four sides of the green at a level of 1 foot above the playing area with a sloping bank 2 ft. 6 in. wide from edge of walk to edge of playing area. This allowance will permit the installation of the standard ditches and banks later should there be a demand for a green on more approved lines.

Work to consist of:

Clear site of all vegetable matter and other rubbish detrimental to the formation of a good turf sward and burn or otherwise dispose of as may be directed.

Strip top-soil from area to a depth of 4½ inches and lay aside on some convenient site for re-use.

Excavate to take out formation level of lawn (and walks, where provided). Excavated materials to be wheeled and deposited where filling is required, put down in layers not exceeding 6 inches deep, and well consolidated. Dispose of surplus excavations as may be directed.

Where walks are provided round green as suggested in the preliminary note, the bank between walk and playing level of the lawn must be trimmed to a uniform slope of 1-foot rise to a horizontal width of 2 ft. 6 in.

As a precaution against worms and other insect pests the formation of lawn and banks must be treated with a 10 per cent. solution of colloidal lead arsenate applied at the rate of 1 gallon to every 25 superficial yards of surface. The earth formation should be well watered immediately before applying the solution to promote more efficient penetration.

Respread top-soil previously removed from site to an even consolidated depth of 4½ inches over area of lawn and banks, dress with powdered vegetable charcoal at the rate of 4 oz. to the superficial yard and fish manure or other approved grassland fertilizer at the rate of 2 oz. to the superficial yard, and thoroughly incorporate in the surface by raking or other means.

Screed over surface to accurate levels and lightly consolidate and at a suitable time sow down with the under-noted mixture of grass seeds at the rate of 2 oz. to the superficial yard. Every care to be taken to ensure even distribution of the grass seed. Seeds thereafter to be lightly raked in to give cover and the surface lightly rolled and top dressed with sharp washed sand at the rate of 6 lb. to the superficial yard.

Seed mixture:

80 per cent. Chewings Fescue.
20 ,, Agrostis tenuis.

Walks round the green to be formed to the widths as shown on drawings, bottomed with mixed clinker and ashes to a consolidated depth of 4½ inches, raked to proper camber, and surfaced with approved binding gravel or hoggin to a consolidated depth of 1½ inches, edges of walks to be supported by 6 by 2 inch pre-cast concrete edging bedded, haunched up, and jointed in cement mortar.

The external banks to walks formed by the cut and fill to be trimmed off to a batter of not more than 1 in 1 soiled and left for planting.

SUGGESTED FORM OF TENDER

(OMIT SECTIONS NOT APPLICABLE)

Dear Sirs,

Proposed Playing Field at .....

We, the undersigned, hereby undertake to carry out the works on the above, all in accordance with the drawings, specifications, and conditions of contract referred to, which have been examined by us, complete for the undermentioned sum as detailed:

		£ s. d.
Preliminaries:	Allow for tools, sheds, conditions of contract, &c.	
Section 1	Clearing site	
,, 2	Preparation, cleaning, and grading	
,, 3	Major levelling	
,, 4	Draining	
,, 5	Liming and fertilizing	
,, 6	Seeding (where not included in other sections)	
,, 7	Cricket squares and practice wickets (grass)	
,, 8	Grass tennis courts	
,, 9	Putting greens	
,, 10	Turfing (where not included in other sections)	
,, 11	Maintenance	
,, 12	Hard tennis courts	
,, 13	Tennis stop-net fencing	
,, 14, 15, 16, or 17	Bowling green	
,, 18	Athletic facilities	
,, 19	Children's playground	
,, 20	Water-supply	
,, 21 or 22	Cycle track	
,, 23	Dry-surface playing area	
,, 24	Concrete cricket wickets	
,, 25	Bowling lawn or croquet lawn	
	Total	£

Should our tender be accepted, we undertake to complete the work within ..... months from date of order.

Your acceptance will be binding on——

Yours faithfully,

SUGGESTED SCHEDULE OF RATES ON WHICH TENDER IS BASED INCLUDING SUPERVISION AND PROFIT AND WHICH SHOULD ALWAYS BE SENT WITH TENDER

(OMIT ITEMS WHICH DO NOT APPLY)

	£ s. d.
Excavating top-soil, moving to spoil heaps within a distance of 100 yards, and subsequently respreading to a uniform thickness	per cubic yard

	£ s. d.
Excavating subsoil, moving to distances not exceeding 100 yards, spreading, and consolidating to required levels	per cubic yard
Ploughing once	per acre
Cultivating once	,,
Disk harrowing once	,,
Tine harrowing once	,,
Chain harrowing once	,,
Grading as specified	,,
Liming (1 ton per acre) as specified	,,
Peat application (30 cwt. per acre)	,,
Fertilizing (fish guano or other approved) as specified	,,
Fertilizing as specified for maintenance	,,
Seeding (as specified)	,,
Turfing (as specified)	per sup. yard
Mole draining or sub-soiling	per yard run
Provide and Lay:	
9-inch main drain as specified	,, ,,
6- ,, ,, ,,	,, ,,
4-inch sub-main as specified	,, ,,
3-inch collecting drains as specified	,, ,,
Laying dry-surface areas	per sup. yard
Laying tar-macadam as specified	,, ,,
Foreman	per hour
Labourers	,,

Materials, including delivery and profit

Turves (3 feet by 1 foot by 1½ inches thick)	per 100
Hydrated lime	per ton
Granulated peat	,,
Fertilizer as specified for maintenance	per cwt.
Chlorate of soda	,,
Colloidal lead arsenate	,,
Creosote oil	per gallon
Fish guano or other approved fertilizer	per cwt.
Seed as specified for outfield	,,
Seed as specified for cricket range	,,
Graded clinker (3 to ¾ inch gauge)	per cubic yard
Fine clinker (½ inch to fine)	,, ,,
Sharp washed sand (⅛ inch down)	,, ,,
Good binding hoggin, 'Redgra', or other approved	,, ,,
Hardcore	,, ,,
Tar macadam	per ton

BOOKS SUGGESTED FOR FURTHER STUDY

Principles of Agriculture, by L. H. BAILEY. (Macmillan & Co. Ltd.)

Soils, their Properties and Management, by LYON, FIPPIN, and BUCKMAN. (Macmillan & Co. Ltd.)

Land Drainage and Reclamation, by AYRES and SCOATES. (McGraw-Hill Book Co.)

Soils and Soil Management, by GUSTAFSON. (McGraw-Hill Book Co.)

The Soil, by Sir A. DANIEL HALL. (John Murray & Co. Ltd.)

Practical Lawncraft, by R. B. DAWSON, Director of Board of Greenkeeping Research. (Crosby Lockwood.)

The Establishment and Care of Fine Turf, by DAVID CLOUSTON. (Wylie & Son, Aberdeen.)

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